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# Environmental Impact Analysis Process

DRAFT

ENVIRONMENTAL IMPACT STATEMENT
ESTABLISHMENT OF THE GANDY RANGE EXTENSION
AND ADJACENT RESTRICTED AIRSPACE AS AN
AREA FOR SUPERSONIC FLIGHT TRAINING

HILL AFB, UTAH 7-20-93

DEPARTMENT OF THE AIR FORCE

**Air Force**
**Environmental Planning Division**
**(HQ USAF/CEVP)**

Room 5B269
1260 Air Force Pentagon
Washington, DC 20330-1260

16 JUL 93

MEMORANDUM FOR DTIC (Acquisition)
(ATTN: Pat Mauby)

SUBJ: Distribution of USAF Planning Documents Forwarded on 1 July 93

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DEPARTMENT OF THE AIR FORCE
WASHINGTON 20330

OFFICE OF THE ASSISTANT SECRETARY

July 20, 1983

TO: ALL INTERESTED GOVERNMENT AGENCIES, PUBLIC GROUPS, AND INDIVIDUALS

Attached for your review and comments, in compliance with the Regulations of the President's Council on Environmental Quality, is the Draft Environmental Impact Statement (EIS) for the Gandy Range, Hill Air Force Base, Utah.

This Draft EIS addresses the proposed action and alternatives to establish airspace in the present Gandy Range Extension Military Operations Area/Air Traffic Control Assigned Airspace Area and adjoining restricted airspace for conducting supersonic flight training.

Please forward any comments not later than ~~September 30~~ October 14, 1983, to:

Environmental Planning
HQ AFLC/DEPV
Wright-Patterson AFB, Ohio 45433

Sincerely,

James F. Boatright

JAMES F. BOATRIGHT
Deputy Assistant Secretary of the Air Force
(Installations, Environment and Safety)

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Draft EIS

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## COVER SHEET

1. Responsible Agency: US Air Force

2. Title of Action: Establishment of the Gandy Range Extension and Adjacent Restricted Airspace as an Area for Supersonic Flight Training.

3. Location of Action (Proposed Airspace is Located Over):

   a. Eastern portions of Elko and White Pine Counties in Nevada.

   b. Western portions of Tooele, Juab and Millard Counties in Utah.

4. Further Information: Any person or agency wishing additional information or a copy of this document may contact:

Public Affairs Office
OO-ALC/PA
Hill Air Force Base, Utah 84056
(801) 777-5201

5. Type of Statement: Draft Environmental Impact Statement (DEIS).

6. Abstract: The action being assessed is to establish airspace in the present Gandy Range Extension Military Operations Area/Air Traffic Control Assigned Airspace Area (MOA/ATCAAA) and adjoining restricted airspace for conducting supersonic flight training. Supersonic flights will be limited to elevations above 5,000 feet above ground level. Military aircraft, primarily F-16 aircraft assigned to Hill Air Force Base, propose to fly up to 1,050 supersonic sorties each month in this airspace. The combination of the Gandy Range and the smaller adjoining restricted airspace are judged to be the preferred alternative considered in addressing the need for additional supersonic flight approved airspace. The most significant environmental impact associated with the proposed action is that due to the generation of sonic booms. The land area beneath the proposed airspace is predominantly BLM land, but does have an estimated 350 residents. Areas beneath the most active portions of the airspace should still experience A-weighted day-night sound levels of less than 65 decibels; levels generally accepted as being suitable for residential purposes. Past studies predict minimal impact on animals and future plans in the area.

7. Comments on this DEIS:

   a. This DEIS was made available to the Environmental Protection Agency and the public on 19 August 1983.

   b. All comments concerning this DEIS should be postmarked by 14 October 1983 and forwarded to:

Environmental Planning
HQ AFLC/DEPV
Wright-Patterson AFB, OH 45433

## SUMMARY

1. Description of Proposed Action:

The proposed action is to establish airspace in the present Gandy Range Extension Military Operations Area/Air Traffic Control Assigned Airspace Area (MOA/ATCAAA) and adjoining restricted airspace for conducting supersonic flight training. The airspace being considered is within Utah Test and Training Range (UTTR) airspace and is a block with its lateral boundaries being defined by the combination of the Gandy MOA boundaries and a smaller area adjoining the Gandy MOA's east side. This smaller area is now within airspace restricted for military operations and will join the Gandy MOA with airspace over DoD owned land that is already approved for supersonic flight. This existing supersonic flight airspace cannot accommodate all of the test and training missions that are now scheduled for the UTTR and which should be accomplished in supersonic flight airspace. The vertical boundaries of the airspace being sought for supersonic flight ranges from 5,000 feet above ground level (AGL) to flight level 580, which is approximately 58,000 feet above mean sea level (MSL). Subsonic flight training is currently being accomplished in this airspace. It overlies the Utah - Nevada border; more specifically, overlies western portions of Tooele, Juab and Millard Counties in Utah and eastern portions of Elko and White Pine Counties in Nevada. Figure A shows the relative location of the proposed airspace which overlies portions of the "Great Basin" area of Utah and Nevada.

Air Force units at Hill Air Force Base, Utah and other units using the UTTR for specific exercises, propose to fly up to 1,050 supersonic flight sorties or missions per month in the airspace under consideration. Each sortie will average between two and three short periods of supersonic flight with a sonic boom being created each time the speed of sound is exceeded. Approximately 100 to 125 sonic booms will be produced per day. Air Force tests and analyses indicate that only 30 percent of these booms will ever reach the ground. Tests and analyses also indicate that any one location on the ground beneath the airspace where the highest Air Force use is expected would experience three or less sonic booms per day 90 percent of the time.

2. Alternatives to the Proposed Action:

The alternatives to the use of the Gandy Range Extension and the adjoining restricted airspace for supersonic flight training that were considered are:

a. No action.

b. Relocating the supersonic flight requirement to some other airspace within the UTTR.

c. Use of distant supersonic flight airspace.

d. Relocating the 388 Tactical Fighter Wing (TFW).

e. Changing the geographic or vertical limits of the proposed supersonic flight airspace.


Figure A
Location Map

These alternaties were summarized as follows:

a. No action to increase the quantity of supersonic flight airspace would restrict realistic training and significantly degrade the wartime effectiveness and survivability of F-16 aircrews. Due to high priority national research and development projects, special exercises and F-16 air-to-ground training, the existing UTTR supersonic flight airspace is unable to accommodate all of the 388 TFW's F-16 air-to-air sorties.

b. Existing restricted airspaces or MOAs making up the UTTR or new areas within 100 nautical miles of Hill AFB are not considered feasible alternatives for supersonic flight training. As compared to the proposed airspace, alternatives for supersonic flight training areas would result in a negative impact on existing military usage, commercial/general aviation traffic and/or would expose significantly more people to sonic boom activity.

c. The capability of sharing supersonic flight airspace managed by other units is limited by the transit distance required to obtain this training. Excluding the UTTR, the nearest supersonic flight airspace is 320 miles from Hill. Costly inflight refueling and long F-16 transit operation would be necessary to support this alternative. The costs, degraded quick reaction deployment posture and operating limitations resulting from deploying a squadron to a satellite location for shared use supersonic flight training are unattractive when compared to local operations within the proposed supersonic flight airspace.

d. Relocation of the 388 TFW is considered impractical because of the desirable attributes of the Hill location and the excessive costs required to move and set up operations at another base, aside from the economic impact on the local community.

e. Changing the geographic or vertical dimensions of the proposed supersonic flight airspace would severely restrict F-16 realistic training opportunities in this area. If the geographic size was reduced, the public beneath the adjusted area boundaries would be exposed to more concentrated sonic boom activity as a result of the smaller operating airspace. Raising the minimum supersonic flight altitude above 5,000 feet AGL would degrade realistic air combat training in the area. If the floor of the airspace were raised above 10,000 feet AGL, training would be seriously degraded because it would have to be accomplished at altitudes that would not represent actual combat situations; and if the floor were raised to somewhere between 5,000 and 10,000 feet AGL, training would suffer because the lower altitudes were not available as a buffer.

3. Environmental Impacts:

The environmental impacts are considered minimal in all respects except the noise resulting from sonic boom activity. The more significant environmental characteristics considered are addressed below:

a. Air quality: The area is presently in use for subsonic flight operations; but if approved for supersonic flight, the number of sorties flown there will probably increase. At the present time, the overflow F-16 air-to-air sorties that cannot be scheduled for existing supersonic flight airspace are scheduled for other available subsonic flight airspace. If the proposed airspace is approved for supersonic flights, it will be the prime location for those overflow sorties. Also, at the higher engine power settings required to achieve and maintain supersonic flight, the rate at which engine air pollutants enter the atmosphere will increase. Based on the high altitude at which flight operations are conducted, the large operating area, and the quantity of air pollutants added by non-point sources, military flying operations are considered to have a relatively insignificant impact upon the air quality. It is possible that as a result of an emergency, fuel would be jettisoned into the atmosphere to reduce the gross weight of a distressed aircraft. Previous operational experience indicates that such occasions are extremely rare. Also, designated jettison areas are located over DoD property and between the Gandy Range Extension and Hill AFB. These areas are to be used when possible.

b. Noise: Although present subsonic jet operations in the airspace under consideration create noise, supersonic flight would result in additional noise impact on the environment beneath and near the area. Several State and Federal agencies commenting on the proposed supersonic flight action have expressed concern regarding the potential adverse impact that frequent sonic booms may have on both the human and wildlife population of the area. Based on calculations of nominal sonic boom overpressures and assuming people beneath the area live at or below 5,000 feet MSL, the maximum overpressure to which individuals should be exposed is 7.48 pounds per square foot (psf), but the overpressures occurring most often should be less than 3.52 psf. These levels of overpressure are not known to cause any health hazards to individuals. The supersonic overpressures may result in claims for broken glass, cracked plaster and public complaints. Under the maximum anticipated use, the cumulative noise from sonic booms in the new supersonic flight airspace will be a C-weighted day-night average sound level of between 58 and 60 decibels. About 12 percent of a population subjected to this noise level can be expected to be highly annoyed. It is estimated that there are less than 350 people living beneath the proposed supersonic flight airspace who may be subjected to these noise levels. The Department of Housing and Urban Development (HUD) generally considers locations with A-weighted day-night average sound levels of less than 65 decibels to be appropriate for residential purposes. Even after applying a 4.5 decibel penalty to the C-weighted values in order to make them more comparable to the annoyance associated with the A-weighted values, the sound levels predicted for the proposed action would still be considered acceptable by HUD for residential development.

Available data indicates wildlife and domestic animals demonstrate limited response and no nestling death or eyrie abandonment when subjected to sonic booms of the level anticipated in the proposed action. Questions on long term protracted exposure and sublevel responses remain to be studied.

Recreational activities now taking place in the land area beneath the proposed supersonic flight airspace are of the outdoor, individual or small group, wilderness experience nature. These are activities where the values of unspoiled nature are deliberately sought. Because of the remoteness of the area, the total number of people participating in these activities is expected to be small. Noise created by sonic booms would probably be annoying to some of the recreationists. Recreational activities associated with the mountainous areas beneath the airspace would probably be impacted less than those associated with valley floors. The sonic booms will not involve any irreversible damage to the recreational capacity of the area. To the fullest extent possible, sensitive periods such as night time and generally weekends, would be avoided, thus further mitigating possible annoyances.

Other than the slight change in quantity and location of aircraft emissions, the environmental impacts anticipated from the proposed action are associated with the production of sonic booms. Other areas of possible impact such as water quality, solid waste and land disturbance are considered insignificant. The impacts of sonic boom noise on people, animals (wild and domestic), structures and land use are worthy of noting.

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## LIST OF FREQUENTLY USED ACRONYMS

| | | |
|---|---|---|
| AFB | - | Air Force Base |
| AFSC | - | Air Force Systems Command |
| AGL | - | Altitude Above Ground Level |
| ATCAAA | - | Air Traffic Control Assigned Airspace Area |
| BLM | - | Bureau of Land Management |
| CO | - | Carbon Monoxide |
| dB | - | Decibels |
| DEIS | - | Draft Environmental Impact Statement |
| DNL | - | Day-Night Average Sound Level |
| DoD | - | Department of Defense |
| EIS | - | Environmental Impact Statement |
| FAA | - | Federal Aviation Administration |
| FL580 | - | Flight Level 580 or approximately 58,000 feet MSL |
| HAMOTS | - | High Accuracy Multiple Object Tracking System |
| HC | - | Hydrocarbons |
| HUS | - | HAMOTS Upgrading System |
| IFR | - | Instrument Flight Rules |
| MOA | - | Military Operations Area |
| MSL | - | Altitude Above Mean Sea Level |
| NASA | - | National Aeronautics and Space Administration |
| NM | - | Nautical Mile |
| $NO_x$ | - | Nitrogen Oxides |
| psf | - | Pounds per Square Foot |
| $SO_x$ | - | Sulfur Oxides |
| $SO_2$ | - | Sulfur Dioxide |

TAC - Tactical Air Command

TFW - Tactical Fighter Wing

UTTR - Utah Test and Training Range

VFR - Visual Flight Rules

WSA - Wilderness Study Area

## DEFINITIONS OF FREQUENTLY USED TERMS

Air Traffic Control Assigned Airspace Area (ATCAAA) - Airspace of defined vertical/lateral limits, assigned by ATC to provide air traffic separation between the specified operation being conducted within the assigned airspace and other IFR air traffic.

Cutoff Mach Number - The aircraft Mach number below which the temperature gradient of the atmosphere refracts the sonic boom in such a way that it does not reach the ground and thus is not heard. Aircraft speeds above the cutoff Mach number will create sonic booms that progagate to the ground. The cutoff Mach number is solely dependent upon aircraft elevation and can be calculated a shown in Appendix B.

Day-Night Average Sound Level (DNL) - The day-night average sound level is a measure of the noise environment over a 24-hour annual average busy day with a 10 decibel penalty to events that occur after 10:00 p.m. and before 7:00 a.m.

dB - Decibel, a logarithmic unit which expresses the ratio between two sound pressures, measuring the relative loudness of sounds. When measuring sound pressure on the decibel scale, in effect, one is comparing the levels with a standard reference pressure which is accepted as corresponding to 0 decibels, about the faintest sound that can be heard by a person with very good hearing in a very quiet location.

Flight Level (FL) - A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Each is stated in three digits that represent hundreds of feet. For example, flight level 250 represents a barometric altimeter indication of 25,000 feet; flight level 255, an indication of 25,500 feet.

Focus Boom - A focus boom occurs when two or more shock waves from an aircraft in supersonic flight converge on the same point in space at the same time causing a buildup of the overpressures. These focus booms, generally caused by supersonic maneuvers or accelerations, do not move with the aircraft, but only occur in one location which can be either in the air or on the ground.

Mach Number - A number representing the ratio of the speed of a body to the speed of a sound in the surrounding atmosphere. Subsonic speeds are represented by numbers less than 1.0, supersonic speeds by a Mach number greater than 1.0.

Military Operations Area (MOA) - An airspace assignment of defined vertical and lateral dimensions, established outside positive control area to separate/segragate certain military activities from IFR traffic and to identify for VFR traffic where these activities are conducted.

Nautical Mile - 1.150 statute miles.

Sortie - A mission by a single military aircraft.

Sonic Boom - An acoustic phenomenon (sound) heard when a object exceeds the speed of sound in air, that is, about 738 miles per hour at sea level and standard atmospheric pressure.

Subsonic - Movement of an object at a speed less than the speed of sound.

Supersonic - Movement of an object at a speed greater than the speed of sound.

# I. PURPOSE OF AND NEED FOR ACTION:

## 1.0 Purpose:

The purpose of the proposed action is to establish additional airspace within the Utah Test and Training Range (UTTR) for supersonic flight. Existing missions at Hill Air Force Base (AFB) in conjunction with special exercises and tests scheduled for the UTTR have made airspace already approved for supersonic flight inadequate in size. This section will further elaborate on the existing UTTR facilities and the mission requirements they must accommodate.

## 1.1 Range Facilities:

### 1.1.1 Range Managers:

The 6501 Range Squadron at Hill AFB is responsible for the overall command, control and management of the UTTR. This Squadron establishes policy that facilitates the efficient and safe use of air and ground space. They also provide for cost-effective acquisition, transmission and processing of time-critical scientific and engineering data.

### 1.1.2 Utah Test and Training Range:

In December 1977, the Deputy Secretary of Defense approved the plan for consolidation of the Hill/Wendover Ranges and the Dugway Proving Ground into a single range. On 1 January 1979, the Air Force Systems Command (AFSC) became the single range manager and the range is now operated as a major training and test facility base, known as the Utah Test and Training Range (UTTR). The AFSC organization performing this managerial task is the 6501 Range Squadron located at Hill AFB. Since the UTTR is operated as a DoD facility, range plans and programs must consider the requirements of all DoD range users. This has allowed a more concise ability to plan for and forecast the total usage of the UTTR. Besides providing a more reliable source of determining range usage than was available in the past, this ability has attracted more DoD training and tests to the range. These two factors, improved planning capability and increased range activity, along with better data available on the training requirements of the F-16 aircraft are the major contributors to the present proposal to establish the additional supersonic flight airspace.

Figure 1.0 depicts the flying training airspaces, restricted airspaces, and Military Operations Areas (MOA) in the vicinity of Hill AFB which make up the UTTR. For convenience, R-6404 and the area of the Lucin MOA's will be referred to in this text as the northern range or northern portion of the UTTR and the remainder of the UTTR to the south as the southern range or southern portion. The UTTR can be divided logically into these two portions since the airspace is divided by a commercial airline corridor and the land area below also forms a corridor between DoD owned lands where an Interstate Highway (I-80) is located. With the 388 TFW's full complement of F-16 aircraft, these flying areas must accommodate approximately 98 F-16 and 18 F-105 sorties per day. They must also accommodate special exercises, research

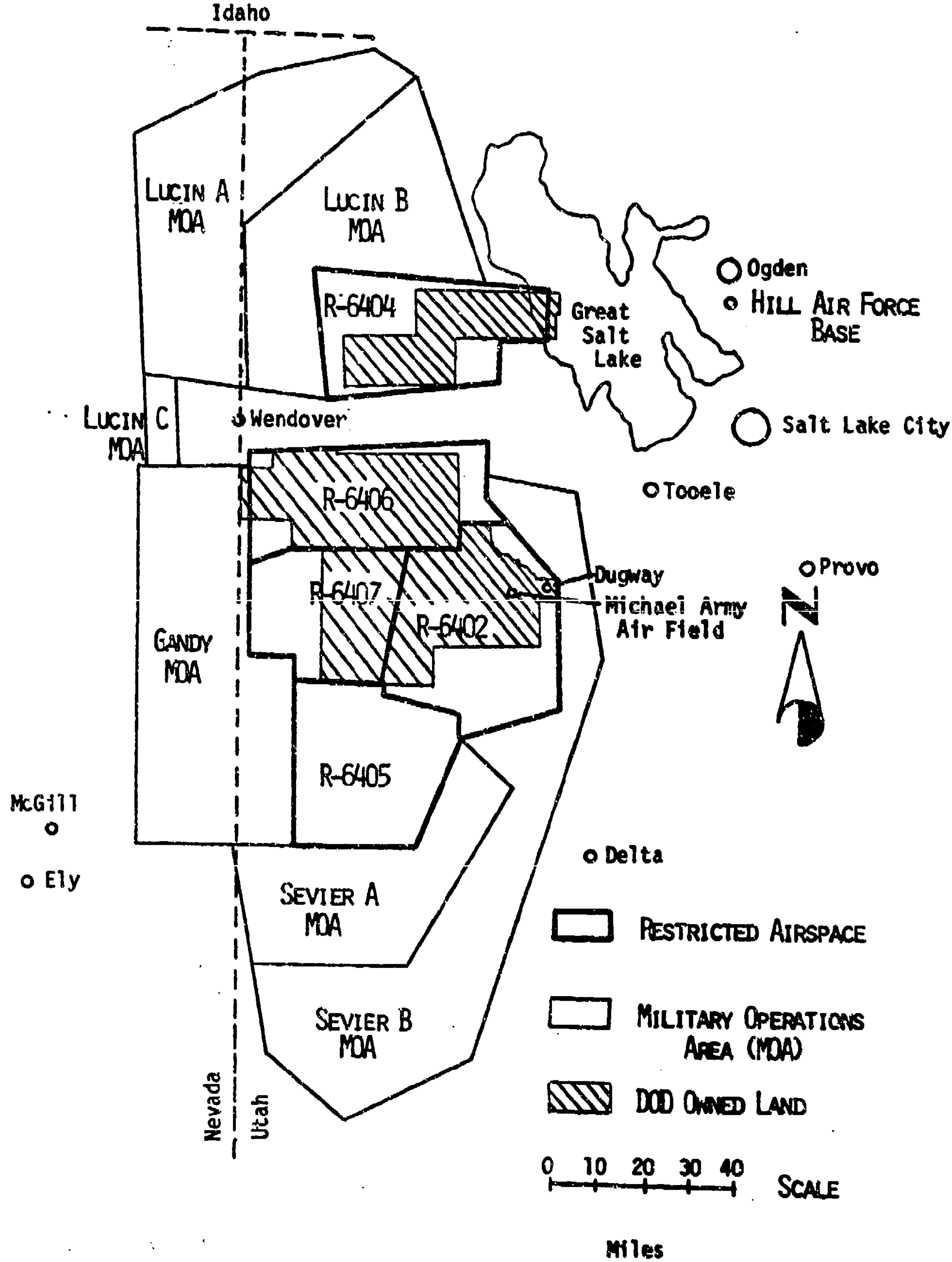



Figure 1.0
Utah Test and Training Range

and development programs and the flight testing of aircraft that have received depot maintenance at Hill AFB.

As part of the development of the UTTR complex there have been approximately 60 High Accuracy Multiple Object Tracking System (HAMOTS) sites installed beneath the airspace making up the range complex. These antenna sites provide position test data on test craft within the area. Twenty-two of these HAMOTS sites were recently installed in the southern range to facilitate the Air Launched Cruise Missile fly-off program which involved the UTTR. The Air Force now proposes to upgrade some of these HAMOTS stations to provide tracking sites for a new, highly sophisticated air combat maneuvers tracking system that is to be installed within the UTTR. Since this new system will be for air-to-air training, it will have to service an area where the most realistic combat maneuvers can take place, i.e., a supersonic flight airspace low enough to accommodate tactical training. At the present time, the only UTTR airspace meeting this description is the "Southern Supersonic Flight Airspace" shown in Figure 2.0, and the HAMOTS sites to be picked for upgrading will be those that can best take advantage of this existing supersonic flight airspace. This instrumentation is being proposed under a program known as the HAMOTS Upgrading System (HUS). Figure 3.0 shows the 35 nautical mile radius circle, designated the HUS Arena, which will be covered by the new tracking system. The inner circle (20 nautical mile radius) shows the extent of the area which will be covered by high resolution tracking equipment and the outer circle (35 nautical mile radius) indicates the limits of the area covered by lower resolution capabilities. Although the center of the HUS Arena is not ideally located with respect to the existing supersonic flight airspace, it is the best location that can be arranged using existing HAMOTS sites; an arrangement that will provide a substantial savings (millions of dollars) to the US Government.

## 1.2 Mission Requirements:

### 1.2.1 The 388 Tactical Fighter Wing (TFW):

The 388 TFW, part of the Air Force's Tactical Air Command (TAC), was activated at Hill AFB in December 1975. With approximately 1800 personnel assigned, the Wing is the largest tenant organization on base. Its mission includes air-to-ground and air superiority roles. When it reached full strength in December 1976, the 388 TFW was equipped with 54 F-4D Phantom II aircraft. In January 1979 the 388 TFW began a phase out of the F-4D aircraft and replacement with F-16 aircraft. The 388 TFW's full strength now accounts for 102 F-16 aircraft. The environmental impact of this action was addressed in the Final Environmental Impact Statement (EIS), "F-16 Beddown at Hill AFB, Utah." In this Final EIS, dated 16 November 1977, it was indicated that airspace already approved for supersonic flight would satisfy the requirements of the F-16 mission. However, partially due to the newness of the aircraft to the Air Force inventory, the number of F-16 training flights requiring supersonic speeds was underestimated at that time. Also, the growing number of test and training operations at the UTTR which require airspace for supersonic flight were not accounted for.

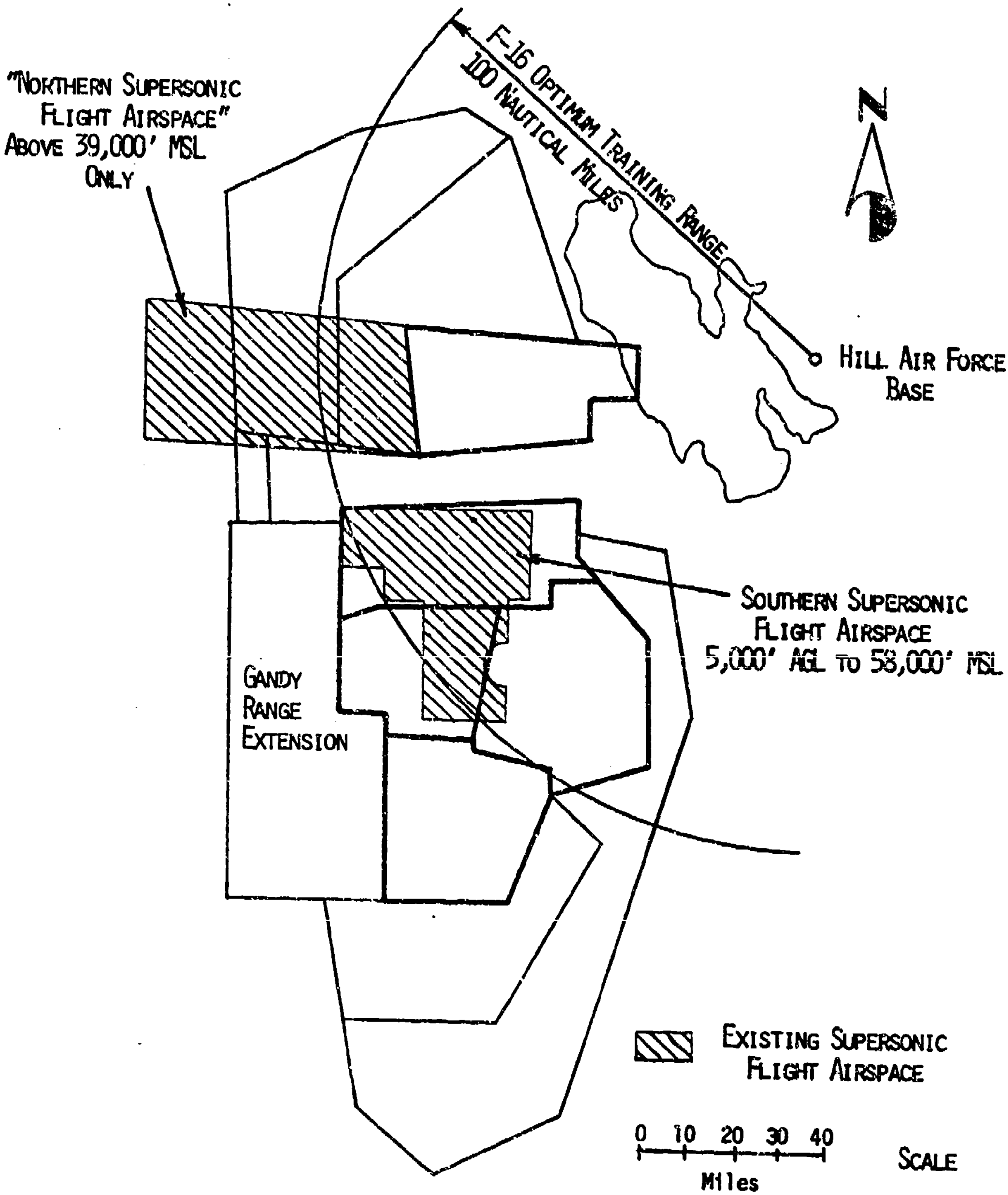
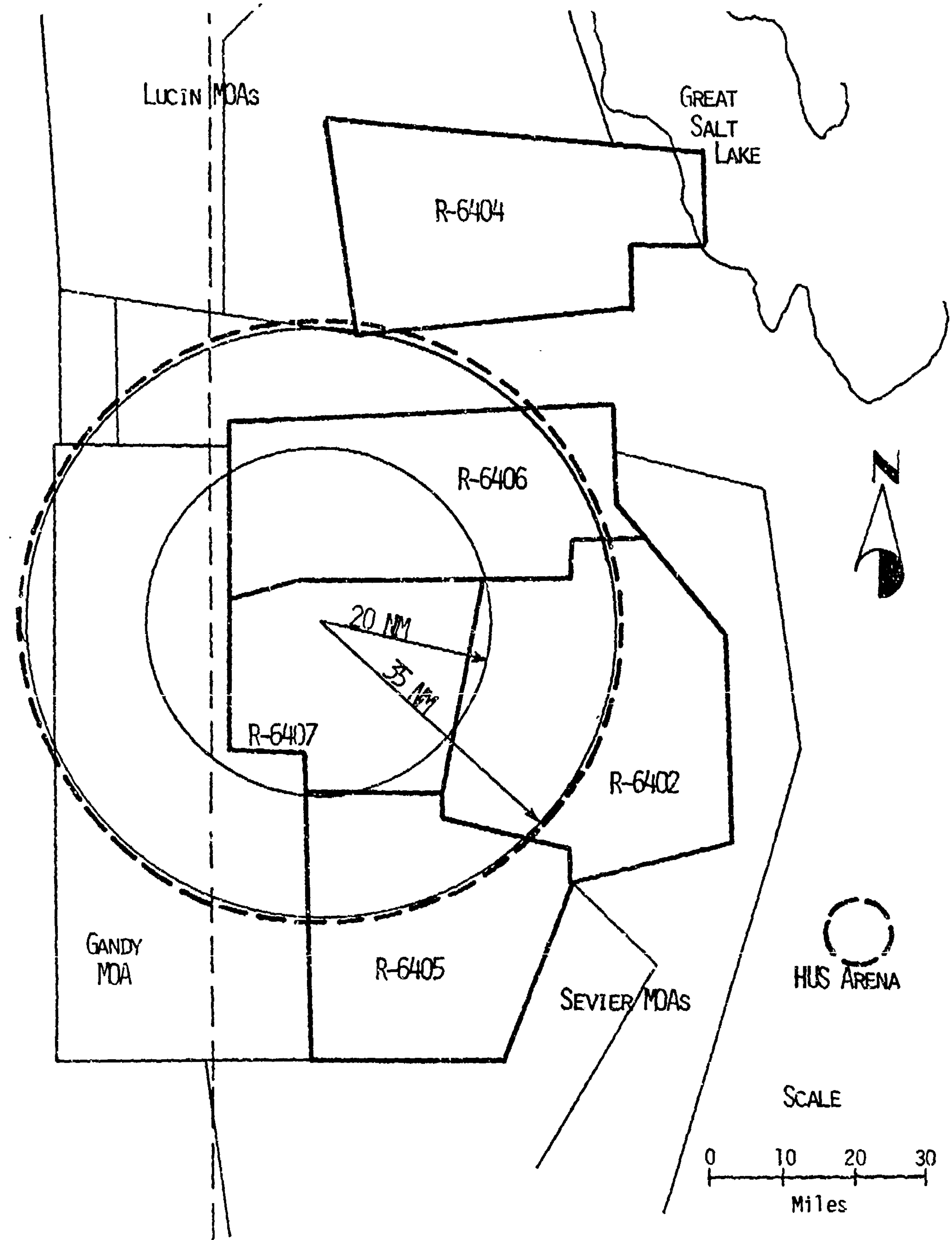



FIGURE 2.0
EXISTING SUPERSONIC FLIGHT AIRSPACE
UTAH TEST AND TRAINING RANGE




20 NM RADIUS - HIGH RESOLUTION
TRACKING AREA
35 NM RADIUS - LOWER RESOLUTION
TRACKING LIMITS

FIGURE 3.0: HUS ARENA

The mission of the 388 TFW is to maintain a state of readiness of personnel and equipment to conduct world-wide air superiority operations against enemy aircraft. An essential element in the effective accomplishment of this mission is realistic aircrew training to insure that in time of conflict, tactical forces are prepared and capable of defeating the adversary. Recent military experience indicates that combat crew effectiveness and their ability to survive hostile environments are directly related to the quality and quantity of previous training received. Airspace requirements for quality training with the F-16 aircraft dictate the use of large supersonic flight training areas to realistically employ the aircraft in the role for which it was designed and procured. To accomplish Tactical Air Command's (TAC) directed mission, training requirements and maintain a high level of unit combat capability, approximately 55 percent of the F-16 training sorties are air-to-air superiority oriented and require supersonic flight airspace. Because of wide variations in training scenarios and individual pilot employment techniques, supersonic flight may not occur on all of the F-16 air-to-air training sorties. Supersonic capability, however, should exist so that pilots may employ the F-16 in that regime if required. Without speed restrictions, the pilots are able to exploit the entire flight regime of the aircraft, a necessity in providing realistic training. Requiring pilots to maintain subsonic speeds would be an artificial barrier that would not exist in actual "wartime" situations. The 388 TFW's air superiority mission is now degraded because adequate airspace in which to conduct air combat training at supersonic speeds is not available.

With its full complement of F-16 aircraft, the 388 TFW mission training requirements dictate 1169 air-to-air sorties ~~per month~~ (approximately 270 per week or 54 per day) with approximately 90 percent (or 1050) of these exceeding the speed of sound. These missions ~~consist of air~~ combat training (dog fight) type missions which require supersonic flight training areas for optimum mission accomplishment. Supersonic flight airspace presently available and appropriate for 388 TFW training is limited to a single airspace designated as "Southern Supersonic Flight Airspace" in Figure 2.0. This southern supersonic airspace is approved for low altitude operation with a base altitude of 5,000 feet AGL and is located over DoD owned, restricted land areas. This airspace is heavily used by tactical units conducting operational training with fighter type aircraft. Because of its size and the large amount of restricted land area lying below, this southern supersonic flight airspace also receives the bulk of the special exercise sorties, the research and development programs and the F-16 air-to-ground sorties (44 per day, 45 percent of the total sorties).

Air Force Regulation 55-34 permits specific supersonic operations above 30,000 feet MSL. Sonic booms from this altitude are not considered significant because the impact of sonic booms normally decreases as the aircraft altitude increases and not all booms reach the ground. However, to maintain realistic training conditions, tactical fighter aircraft must generally operate and train in the air regime below 25,000 feet MSL. The airspace identified in Figure 2.0 as the "Northern Supersonic Flight Airspace" is an Air Traffic Control Assigned Airspace Area (ATCAAA) between 39,000 and 50,000 feet MSL specifically identified for the flight testing of aircraft that have received depot maintenance at Hill AFB. Supersonic speeds are a routine part of this flight testing. Technically neither this airspace nor any other ATCAAA airspace above 30,000 feet MSL require the "supersonic flight" designation to be used as such; but since this particular airspace is used routinely at supersonic speeds, it is often referred to as a supersonic flight airspace. The proposed action is requesting supersonic flight designation from 5,000 feet AGL all the way up to 58,000 feet MSL.

Also, shown in Figure 2.0 is a 100 nautical mile (NM) radius from Hill AFB identified as the F-16's optimum training range. The 100 NM distance is the practical training limit for the two seat version of the F-16 when it is in a clean configuration (no external fuel tanks). This version of the F-16, designated the F-16B, is used extensively for new pilot training at Hill AFB. The single seat F-16 has a larger fuel capacity than the F-16B, but like the F-16B, normally performs air-to-air training sorties in a clean configuration. Therefore, for an air-to-air training airspace to meet all of the 388 TFW's requirements, one factor is that it be within or close to the 100 NM limit. However, this practical distance limit is extended somewhat for the single seat F-16. The greater distance the training area is located from the optimum training range, the less time and fuel is available for actual training maneuvers unless a refueling tank is used. Routine inflight refueling is considered impractical because the large number of sorties involved would require several tankers and the added cost and fuel consumption would be significant. If the training range radius shown in Figure 2.0 were extended in all directions from Hill AFB there would be no restricted airspace or MOAs available other than those already depicted. Although outside the 100 NM radius, the Gandy Range Extension is being proposed as a supersonic flight airspace because it is close enough that the extra distance is considered an acceptable trade off when compared to the alternatives.

1.2.2 The 419 Tactical Fighter Wing:

It should be noted that the 419 Tactical Fighter Wing (TFW) located at Hill AFB is also a part of TAC and is assigned 18 F-105 aircraft. The 419 TFW also uses UTTR airspace, however, they are relatively small in size compared to the 388 TFW (18 versus 102 aircraft) and their training scenarios do not normally include supersonic speeds. The 419 TFW's present training operations can be roughly broken down into 15 percent for air-to-air and 85 percent for air-to-ground. The air-to-ground sorties are performed predominately in R-6404 (see Figure 1.0), north of existing or proposed supersonic flight airspace. The air-to-air sorties are performed in the same areas as are 388 TFW air-to-air sorties; but since they do not usually involve supersonic speeds, they are not included in the UTTR's present requirements for supersonic flights. The 419 TFW is now scheduled to replace their F-105 aircraft with the F-16 aircraft. The details of this conversion is addressed further under section 2.1.4.

1.2.3 Special Tests and Exercises:

The range area is already receiving very heavy usage. To support this fact, the monthly range activity report for June 1982 shows 3,770 aircraft sorties being flown in the range area. Of this number 3,226 were flown by tactical units conducting operational training. Not all of these sorties exceeded the speed of sound, but because of tactical target requirements combined with supersonic flight requirements, most had to be scheduled in the southern restricted airspace. One of the highest single day activities occurred during a past TAC Red Flag Exercise when 164 low level sorties involving supersonic flight were flown. This is a much higher sortie rate than can be accommodated with normal air-to-air sorties. The Red Flag training scenarios involve large groups of opposing aircraft while the normal air-to-air sorties accomplished within the UTTR involve much smaller groups of opposing aircraft or even one-on-one type training. In 1978 TAC conducted four Red Flag Exercises on the range. Each of these exercises involved composite missions of 50 to 60 aircraft simulating realistic air combat and lasted about 28 days. All Red Flag missions are scheduled in supersonic flight airspace. As indicated before, with AFSC taking over managerial duties for the range, test activity has increased. As an example of new missions which might use the range, project managers for the Advanced Medium Range Air-to-Air Missile (AMRAAM) and the Advanced Strategic Air Launched Missile (ASALM) have conducted site surveys on the range for the feasibility of supersonic flight test operations.

The southern portion of the UTTR now has the only low level supersonic flight airspace readily available to tactical aircraft based at Hill AFB and it is located entirely over DoD restricted land area. This land area also contains many tactical ground targets used for air-to-ground training. As would be expected, these targets must be located in restricted land areas. A conflict sometimes arises when air-to-air and air-to-ground missions are required to be scheduled at the same time and must compete for the same airspace. Although the air-to-ground training can usually be scheduled below air-to-air flights, when a conflict does arise, the air-to-air training will often lose out since ground targets cannot be moved. The air-to-air training will have to be scheduled for adjoining airspaces that are not located over restricted land areas. However, whenever this occurs the viability or realism of these air-to-air training missions are seriously degraded, particularly for the F-16, because no low level supersonic flight airspace is available in these adjoining airspaces.

## II. DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES:

### 2.0 General:

For optiumum combat capability, the 388th Tactical Fighter Wing will require additional airspace, approved for supersonic flight, capable of handling up to 1169 sorties per month including an estimated 1050 with supersonic speeds.

### 2.1 Description of Proposed Action:

#### 2.1.1 Proposal:

The proposed project provides for the establishment of an additional area of supersonic flight west of the existing southern supersonic flight airspace. The majority of the airspace being sought for supersonic flight is now designed as the Gandy Range Extension and the remainder is adjacent to the east-central portion of the Gandy Range. The Gandy Range Extension is now an established Military Operations Area (MOA) from 100 feet above ground level (AGL) to 18,000 feet above mean sea level (MSL), and an Air Traffic Control Assigned Airspace Area (ATCAAA) from 18,000 feet MSL to 58,000 feet MSL. The adjoining portion is currently within airspace restricted for military operations from ground level to 58,000 feet MSL. Subsonic aircraft training is currently conducted in this airspace of concern, which overlies the Utah-Nevada border and more specifically, overlies western portions of Tooele, Juab and Millard Counties in Utah and eastern portions of Elko and White Pine Counties in Nevada as shown in Figure 4.0. The Air Force proposes to conduct aircraft training in this same airspace that will include supersonic speeds, but only when operating above 5,000 feet AGL. The valley areas beneath the airspace are at approximately 5,000 to 6,000 feet MSL. Over these areas the 5,000 feet AGL minimum can be translated to 10,000 to 11,000 feet MSL.

The majority of the training will be conducted by the 388 Tactical Fighter Wing (TFW) stationed at Hill Air Force Base (AFB), Utah, using the F-16 aircraft. Although other type aircraft may participate in training exercises within the proposed airspace, their usage is estimated to be less than 10 percent of the F-16 usage. Because of their shape and size, other aircraft may create sonic booms of greater intensity, but since a vast majority of the aircraft training involving supersonic speeds will be by F-16 aircraft, characteristics of this aircraft will be used throughout this document to evaluate the impact of the proposed action.

It is estimated that under the heaviest scheduling conditions 850 to 1050 aircraft will go supersonic per month within the additional supersonic flight airspace. All supersonic flight activity will be logged on Air Force Form 121 in accordance with Air Force Regulation (AFR) 55-34. All flights will be conducted in visual meteorological conditions (VMC) during daylight hours. Normally, the aircraft will remain at supersonic speeds for only short periods of time (averaging about 15 seconds) while maneuvering. Previous Air Force operational experience with the F-15 indicates the aircraft were supersonic 2.5 times per sortie with less that one third (0.3)

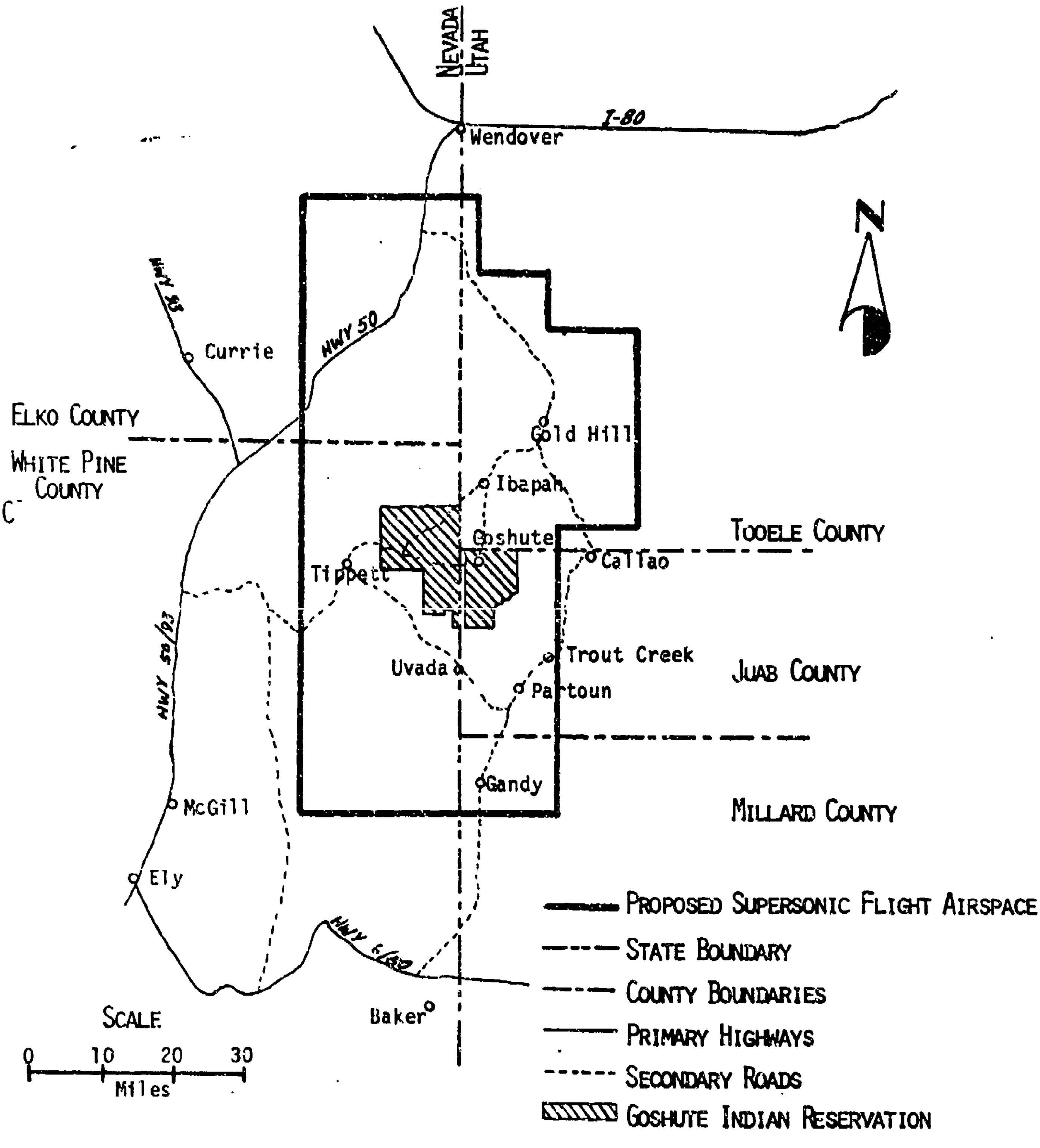



FIGURE 4.0
SITING OF PROPOSED AIRSPACE

of the booms created propagating to the ground. Since the F-15 and F-16 use similar air-to-air training scenarios and are similar in shape, the results of the F-15 will be used for the F-16 in this document.[41] Therefore, assuming 21 or 22 operational days each month, there will be 100 to 125 booms created per day within the proposed supersonic flight airspace under full use and the ground beneath the airspace, approximately 3,030 square miles, would probably be subjected to only 30 to 38 booms per flying day.

The figure of 850 to 1050 aircraft going supersonic per month in this airspace is the maximum anticipated. Existing supersonic flight airspace over DoD property in Utah can handle a portion of the training requirement and will be used to the fullest extent possible. If any F-16 sorties are accomplished over DoD property, the number accomplished in the proposed supersonic flight airspace will decrease accordingly. However, the airspace over restricted property is used heavily for daily training involving ground targets. Also, this area is normally scheduled for special exercises and development tests which are occurring on an increasingly frequent basis. Therefore, should the proposed airspace be approved for supersonic flight training, it is anticipated that maximum usage will occur frequently.

2.1.2 Background of Proposed Supersonic Flight Airspace:

The Gandy Range Extension portion of the proposed supersonic flight airspace was established as a subsonic flight MOA from 1500 feet AGL to 18,000 feet MSL in 1976. However, the military had been using this airspace prior to this action. Air Force flying organizations stationed at Hill AFB had been performing low level intercepts, air combat maneuvering, air refueling, aerial reconnaissance and close air support tactics in this area for a number of years prior to 1976. It was established as a MOA so that the area would be charted on enroute low altitude and sectional charts to warn low altitude traffic of the possibility of activity. Because of operational training requirements, the base altitude of the MOA was lowered to 100 feet AGL on 23 March 1978. The ATCAAA altitude extends from 18,000 feet MSL to FL580, approximately 58,000 feet MSL.

The remaining portion of the proposed supersonic flight airspace is airspace that has been restricted for military usage since the early 1940s. It has been used heavily by both Army and Air Force aircraft as they approach and depart ground targets located within the DoD land to the east. It has also been used extensively for flight maneuvers and air combat training. The altitude of this restricted airspace extends from ground level to FL 580.

The proposed supersonic flight airspace, located over the Utah-Nevada border, has boundaries as depicted in Figures 4.0 and 5.0. A detailed geographic coordinate/map description is provided in Appendix A. The airspace has complete radar coverage down to 15,000 feet AGL from the 299th Communications Squadron's radar antenna located on a 9,300 foot mountain south of Ogden. Much of the airspace below 15,000 feet AGL is also covered by radar from an antenna located at Wendover. It will provide coverage over the northeast portion of the proposed airspace and much of the airspace between 5,000 and 15,000 feet AGL in the central portion. But, because of the mountainous terrain, radar coverage below 15,000 feet AGL is limited in

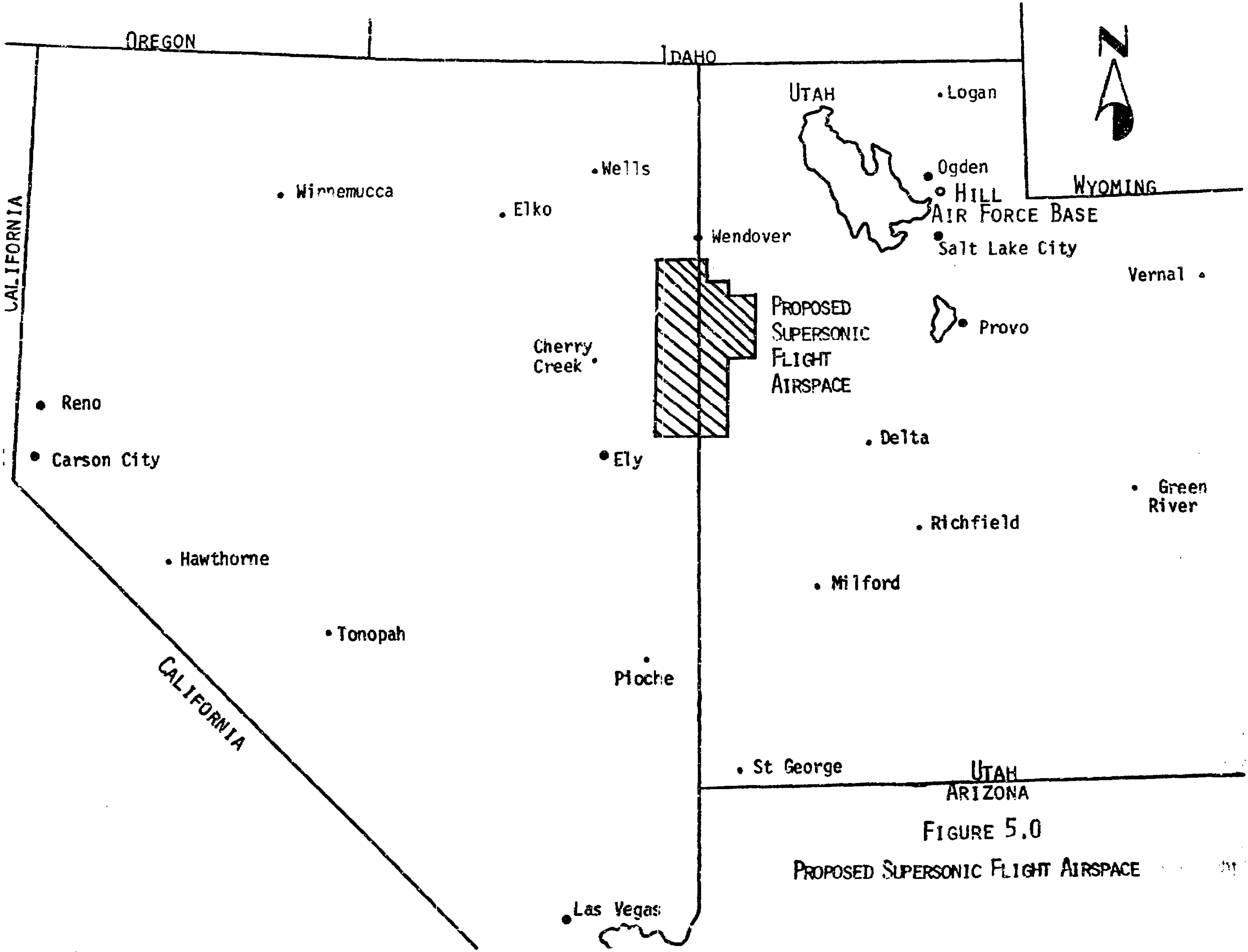



FIGURE 5.0

PROPOSED SUPERSONIC FLIGHT AIRSPACE

the southern portion that lies within the Gandy airspace. There is a proposed radar modernization project that will locate a "gap filler" radar site at Tippett, Nevada, which will complete the airspace's radar coverage between 5,000 and 15,000 feet AGL and lower. Funds have not yet been approved for this project, so it is not known when it will be constructed. At the present time, 1986 is looked at as an optimistic completion date.

When in airspace with radar coverage, a flight that drifts toward the edge of the supersonic flight airspace will be warned by the 299th Communications Squadron over UHF radio. As a backup, flight leads will use ground references combined with the F-16's Inertial Navigation System to remain within the area. As shown in Figure 1.0, the proposed supersonic flight airspace is adjacent to and partially within an existing restricted airspace, much of which is located over Department of Defense property that makes up part of the land area of the UTTR.

Because of it's location, the proposed supersonic flight airspace is used extensively by aircraft moving into and out of ground target and air combat training areas within the inner portions of the UTTR. It is estimated that 70 to 80 percent of the aircraft performing training in the southern portion (that portion south of Interstate Highway I-80) of the UTTR pass through some part of the Gandy Airspace during their mission. Many of these ingress and egress type operations occur beneath the altitude proposed for supersonic flight, but all will continue whether or not the proposed action is ultimately approved.

### 2.1.3 Training in the Proposed Supersonic Flight Airspace:

The airspace under consideration is presently used for 200 to 300 subsonic flight sorties per month. (This does not include the aircraft passing through this airspace to reach some other designated training site.) The following is a description of the flight operations conducted within this airspace by the 388 TFW. The F-16 training programs have been developed after careful analysis of previous experiences and known and postulated adversaries. All flight training programs are designed to provide participating pilots with the most demanding and realistic combat training possible.

#### 2.1.3.1 Transition Training:

Transition training is the initial aircraft familiarization phase for pilots transitioning from other aircraft such as the F-4 to the F-16. It is the first phase of tactical training and provides the pilot with basic skills, proficiency and knowledge in the operations and handling charaecateristics of the new aircraft. Transition training is presently conducted in the airspace being proposed for supersonic flight with flights consisting of two aircraft restricted to subsonic airspeeds. By operating in the subsonic flight regime only, pilots are denied valuable training experience in exploring the performance and handling characteristics of the aircraft as it exceeds and comes back down through the speed of sound. Because of its on-board computer, the F-16 performs these maneuvers differently (from a pilot's standpoint) than most other fighter aircraft in the Air Force inventory. Effective training is further degraded because a great deal of the pilot's attention must be devoted to restricting the aircraft to subsonic airspeeds. Since pilots must continually reference the cockpit airspeed indicator, concentration on the specific mission learning objectives is impeded.

2.1.3.2 Basic Fighter Maneuvers:

After completing transition training, pilots enter the basic fighter maneuver stage of air-to-air training. Flights consisting of two aircraft practice standardized offensive and defensive maneuvers both singularly and in combination. Pilots develop the aerial skills, judgment, and weapons systems knowledge to effectively fly their aircraft in the three dimensions relative to an airborne adversary--the objective being to maneuver the aircraft efficiently to negate a potential threat while achieving a position of advantage for simulated weapons launch. This training is conducted at altitudes from 15,000 MSL to the top of ATC assigned airspace. Although supersonic airspeeds are required to optimize training within this airspace, airspeeds are currently restricted to the 150 knots to .99 Mach range. This stage of training is the pilot's first exposure to the three dimensional aerial arena. The establishment of tactically sound habit patterns, proficiency, and familiarity with aircraft performance characateristics is critical to the success of more complex future training. In addition to the training distraction caused by monitoring the airspeed indicator, the lack of experience in the supersonic flight regime impairs the accomplishment of realistic and tactically sound training.

2.1.3.3 Air Combat Tactics Training:

In Air Combat Tactics Training, pilots sharpen their tactical employment skills while developing new and innovative combat tactics. Air combat tactics require a comprehensive training profile designed to insure the best possible tactical employment of flights consisting of more than one aircraft. Basic Fighter Maneuver training pits the individual pilot against a designated adversary. Air Combat Tactics, however, concentrates effective employment of up to four aircraft as tactical partners or as a team to maintain offensive and defensive mutual support. Sophisticated radar and visual identification systems are employed at long-range to arrive at a visual close-in, three dimensional air-to-air engagement (dogfight). Currently, airspeeds are restricted to subsonic in this airspace. Realistic and tactically sound Air Combat Tactics training in the area is severly degraded because of this speed restriction. As previously stated, reference to the airspeed indicator becomes a training distraction, and there is no opportunity to practice tactics and establish habit patterns during supersonic flight -- the employment regime required for wartime survivability.

2.1.3.4 Dissimilar Air Combat Tactics:

Pilots in Dissimilar Air Combat Tactics training employ air combat tactics against simulated adversaries using various types of aircraft such as the F-5, F-4, or A-7. The objective of the training is to provide each pilot with experience against Navy and Air Force Fighter aircraft which closely resemble specific Soviet made aircraft in size, performance, and tactical capabilities. Flight size varies from four to eight aircraft with airspeed and altitude parameters the same as Air Combat Tactics training. At present, this training is conducted above the DoD owned lands of the southern range so that supersonic flight can be achieved during the engagements.

2.1.4 Quantities of Proposed Training:

The 388 TFW's full complement of F-16 aircraft generates 2125 sorties per month. Of these, 55% (1169) will be sorties involving air-to-air weapons. Ninety percent of these 1169 sorties (or 1050) will actually involve supersonic flight; however, for optimum training capabilities all air-to-air sorties should be flown in airspace where supersonic flight is allowed. Airspace now approved for supersonic flight will handle a maximum of 450 of these air-to-air sorties. This capacity should not change in the future and the testing and training activities that occasionally override the airspace's ability to support these air-to-air sorties should also continue in the future. Range planners estimate a minimum of three large scale tactical exercises (such as the Red Flag exercise mentioned earlier) will be scheduled for the UTTR each year with an additional 2000 sorties per year requiring airspace approved for supersonic flight. These sorties will normally be scheduled for the existing supersonic airspace over DoD land and will decrease the number of 388 TFW sorties that can be scheduled there. With the advent of more sophisticated, longer range projects in the future, an increase in UTTR usage is expected from research and development projects. Examples are the B-1 Penetration Bomber, the ALCM (Air Launched Cruise Missile - continued testing), the GLCM (Ground Launched Cruise Missile), the WAAM (Wide Area Antiarmor Munition), the ASALM (Advanced System Air Launch Missile), and the AMRAAM (Advanced Medium Range Air-to-Air Missile).

It is anticipated that future operations will continue such that existing low level supersonic airspace (south range) will accommodate no more than 450 of the 388 TFW's monthly air-to-air sorties. At times, scheduling air-to-air sorties for this area will continue to conflict with special exercises, research and development projects, and the 956 monthly F-16 air-to-ground sorties, all three of which must be scheduled for airspace over DoD controlled land. Although it has no low level supersonic flight airspace, the northern range does consist of a considerable amount of DoD controlled land and it is used extensively for air-to-ground training. However, much of the northern range is used for static testing of munitions, airmunitions, solid propellant motors and others. The air-to-ground training it accommodates involves most of the 419 TFW's demands. It would be impractical to except the north range to handle a significant portion of the 388 TFW's air-to-ground workload, and as can be seen in Figure 1.0, the DoD owned land within this northern range area is shaped such that airspace directly above it would not accommodate much air-to-air training. In fact, even if all of the airspace above DoD owned land within the UTTR were approved for supersonic flight, there would still not be adequate space to meet all supersonic flight requirements.

If the airspace under consideration is approved for supersonic flight above 5000 feet AGL, the normal monthly scheduling would consist of the maximum use of the airspace over DoD land with the remainder going to this new supersonic airspace. Without other operational conflicts, this monthly schedule would then be 450 F-16 air-to-air sorties in airspace over DoD land already approved for supersonic flight and 719 F-16 air-to-air sorties (1169 less 450) in the proposed airspace. Since 90 percent of these sorties normally involve supersonic flight, this translates to 405 and 647 sorties respectively with supersonic flight. However, when conflicts arise over scheduling operations in airspace over DoD owned land, part or all of the 450 air-to-air sorties normally performed there will be moved to the proposed airspace. When all sorties are scheduled for the proposed airspace, the worst condition exists of 1169 air-to-air sorties with 90% of these, or about 1050, sorties involving supersonic speeds. For the purpose of this document, 850 to 1050 supersonic flights are assumed to be worst condition and will be used to gauge the impact of the proposed action. Range planners anticipate that this will be a maximum loading for the foreseeable future. The airspace could possibly handle more flights but it is questionable whether Hill AFB could support a significantly larger number of aircraft than at present.

As previously mentioned in paragraph 2.1.1, if the proposed airspace is used for training involving supersonic speeds, the entire airspace will experience 100 to 125 sonic booms per day under worst conditions with 30 to 38 booms being heard at ground level. Table 1.0 provides the normal and worst case distributions for the air-to-air sorties. Based on data obtained by the Air Force on the F-15 aircraft, the average airspeed used during supersonic flight periods will be about Mach 1.1. With their experience in the F-16, local pilots estimate the average airspeed during supersonic flight is also about Mach 1.1 and the maximum airspeed normally used in their training configuration is Mach 1.3.

An additional factor that should be considered in the area of future operations is the 419 TFW changing aircraft. At the present time it is programmed that this organization will replace their F-105 aircraft with the F-16. As described earlier, the total number of sorties flown by the 419 TFW are small in comparison to the number flown by the 388 TFW. When the 419 TFW changes aircraft it is anticipated that the number of aircraft and the volume of training may eventually increase over present levels, up to about 24 sorties per day or 120 per week. It is also anticipated that training requirements for the newly assigned aircraft would dictate that 55% of these sorties be for air-to-air sorties; all of which will probably require supersonic flight airspace for optimum results. Therefore, assuming the 388 TFW training requirements remain the same, these 419 TFW sorties may increase the total number of supersonic flights out of Hill AFB by about 24%.

TABLE 1.0

SCHEDULING DISTRIBUTION FOR F-16 AIR-TO-AIR SORTIES

| | Proposed Supersonic Flight Airspace | Existing Supersonic Airspace Over DoD Land |
|---|---|---|
| **Normal Distribution** | | |
| Sorties/Month (Week)* | 719 (166) | 450 (104) |
| Supersonic Sorties/Month (Week) (90% of sorties) | 647 (149) | 405 (94) |
| Booms/Month (Week) (2.5 booms/supersonic sortie) | 1618 (374) | 1012 (234) |
| Booms Reaching Ground/Month (Week) (30% of booms produced) | 485 (112) | 304 (70) |
| **Worst Case** | | |
| Sorties/Month (Week) | 1169 (270) | 0 |
| Supersonic Sorties/Month (Week) (90% of sorties) | 1052 (243) | 0 |
| Booms/Month (Week) (2.5 booms/supersonic sortie) | 2630 (608) | 0 |
| Booms Reaching Ground/Month (Week) (30% of booms produced) | 789 (182) | 0 |

* Weekly operations are obtained by multiplying the monthly number by 12 and dividing by 52. The daily operations can then be obtained by dividing the weekly number by 5.

The number of supersonic flight sorties to be flown in the proposed supersonic flight airspace does not include 419 TFW sorties, but it is a worst-case condition when considering the other training flights. For practical purposes, the existing supersonic flight airspace should usually, if not always, be able to accommodate at least 176 air-to-air sorties per month and the worst-case condition of 1050 supersonic flight sorties per month within the proposed airspace is still applicable. Also, one fifth of the 419 TFW's air-to-air sorties will be flown on Saturdays when there should be very little competition for the existing supersonic flight airspace over DoD land. It can be assumed that all supersonic flight activities on Saturday will be scheduled for this existing airspace. Since the 419 TFW's conversion to a more advance aircraft is only programmed at this time and may be several years before it is implemented, their supersonic flight requirements were not specifically included in the loading estimate for the proposed supersonic flight airspace. But, the loading condition being addressed was exaggerated to account for such a future additional requirement. As long as the 419 TFW's future operations do not significantly increase over those described earlier, the worst-case condition assessed by this document should not be exceeded.

The 388 TFW could also fly weekends but this would do little, if anything, to decrease the need for additional supersonic flight airspace. To significantly increase the number of air-to-air sorties flown over existing supersonic flight airspace (thereby reducing the number that would necessarily be assigned to the proposed airspace), the 388 TFW would have to spread their weekly number of sorties over a seven day week rather than the normal five day flying week. This still would not preclude the need for additional airspace approved for supersonic flight because the number of sorties would still exceed the normal capacity of the existing supersonic flight airspace. Also, and possibly more importantly, there are definite advantages to the 388 TFW flying on weekdays only: (1) they often utilize the non-flying days to catch up on necessary aircraft maintenance; (2) the 419 TFW reservists and pilots on temporary duty have a more unhindered opportunity to use the UTTR facilities on at least one day per week (Saturdays); (3) a significant increase in weekend operations out of Hill AFB would probably cause noise complaints from nearby residents; and (4) weekend flying would adversely impact the moral and welfare of the military families since weekends are the best times for many family activities.

2.1.5 Locations of Proposed Training:

As might be expected, once the HAMOTS Upgrading System (HUS) tracking equipment is installed (see section 1.2.1), the HUS Arena will generally be the area of first choice for scheduling air-to-air sorties. Looking at the geography of the land area below the proposed supersonic flight airspace (see Figure 7.0), there are generally three areas over which combat manuevers would usually take place. This is because pilots will normally choose valleys or flat areas to work over so they can maneuver in their optimum elevation region (around 20,000 feet MSL) without worrying about mountain peaks cutting down the safety buffer or depth of airspace below them. The three areas are in the north, middle, and south of the airspace. The north area is in the north end of the Gandy Range Extension. The middle airspace runs north and south over the Antelope Valley area in the middle of the Gandy airspace. The south area is located south of the Kern and Deep Creek Mountains. The north and middle areas would both lie within the HUS Arena. The eastern side of the proposed supersonic flight airspace will also increase the space available for combat maneuvers now being accomplished over the existing supersonic flight airspace.

The existing supersonic flight airspace over the southern range will frequently be overloaded with tests, exercises and air-to-ground sorties. In these cases, particularly if approved for supersonic flights, the proposed supersonic flight airspace will be scheduled for most of the 388 TFW's air-to-air sorties. With all 1169 monthly air-to-air sorties being accomplished in the new supersonic flight airspace, it is estimated that about 75 percent will be accomplished in airspace that is within the HUS Arena. (This is about maximum loading for this airspace.) The remaining 25 percent would be accomplished in the southern portion of the Gandy airspace that is not within the HUS Arena.

When existing supersonic flight airspace is not saturated with other activities, it will handle a portion of the total monthly air-to-air sorties. When this portion is 25 percent or more, the remaining sorties will all be scheduled for that part of the new supersonic flight airspace that lies within the HUS Arena and the airspace outside the HUS Arena will not be used. In other words, the southern portion of the proposed supersonic flight airspace that is not within the HUS Arena will be the last choice for scheduling air-to-air sorties. The HUS program does include a study to expand the upgraded HAMOTS sites to the south, providing complete coverage for all of the Gandy airspace. However, this option is considered too expensive to pursue at this time and there are no plans in the foreseeable future to make this part of the HUS package.

## 2.2 Alternatives to the Proposed Action:

Alternatives to the use of the Gandy Range Extension and the adjoining restricted airspace for supersonic flight training for F-16 aircraft stationed at Hill Air Force Base are discussed below.

### 2.2.1 No Action:

Acceptance of the No Action option would limit local F-16 supersonic training to the existing supersonic flight area in the southern portion of the Utah Test and Training Range (UTTR). As stated in section 2.1.5, due to high priority national research and development projects, special exercises and F-16 air-to-ground training, the UTTR supersonic flight area may sometimes be unable to accommodate the local supersonic F-16 air-to-air sorties. During these periods when air-to-air training could not be scheduled for the existing supersonic flight airspace, these F-16 sorties would require accomplishment in restricted airspace outside of DoD property and in surrounding MOAs (including the Gandy Range Extension) where subsonic flight restrictions would significantly degrade the conduct of realistic tactical training.

On F-16 air-to-air training sorties scheduled out of existing supersonic flight airspace, pilots would be denied required combat training in the aircraft performance envelope above Mach 1. Mission training effectiveness would suffer because much of the pilots attention would be devoted to restricting the aircraft to subsonic speeds. Since pilots must continually reference the cockpit airspeed indicator to avoid supersonic flight, full concentration on the specific mission learning objectives would be interrupted. Most importantly, with no supersonic flight training on a large percentage of the F-16 missions, the opportunities for pilots to develop, practice and refine sound combat tactics and habit patterns in the supersonic flight regime would be curtailed and combat effectiveness and survivability would be significantly reduced.

The impact of no action may mean that we accept a training program that is not totally responsive to known wartime threats. If F-16 combat pilots are to be prepared to defend the national interest of the United States, peace time training programs must be realistic and tailored directly to expected threats. When aircrews are required to train in a manner totally different from that required for combat, the wartime effectiveness and survivability of that weapons system is degraded. The key element missing from Hill AFB F-16 realistic training is the capability for supersonic flight on every daytime tactical mission. Until this deficit, affecting both the quantity and quality of aircrew combat training is resolved, the 388 TFW will be unable to maintain optimum combat capability.

2.2.2 <u>Consider Other Areas for Supersonic Flight Training:</u>

2.2.2.1 Supersonic Flight Areas Selection Criteria:

Criteria established for evaluating additional supersonic flight airspace for the 388 TFW are as follows:

(1) As an optimum the area should be located within 100 nautical miles (115 statute miles) of Hill AFB to minimize the time/fuel required to transit to and from the area. Fuel consumption associated with afterburner operation during supersonic flight air combat training is responsible for limiting the best distance between home station and training area to 100 NM. This 100 nautical mile criteria is applied to the F-16 training area alternative analysis since greater distances would preclude a sufficient amount of time devoted to actual supersonic flight air combat training on each sortie. A significant reduction of training time in this manner would severely impair the unit capability of meeting mission requirements.

(2) As required by Air Force and FAA regulations, the area should be located in airspace transited by little commercial and general aviation traffic and servicing limited established airports. These criteria avoid/minimize the impact which military flight operations may have on other airspace users.

(3) The area should be very sparsely populated so that the fewest number of people are affected by the noise impact resulting from supersonic flight training.

(4) The size of the area must be large enough to allow effective use of the F-16's radar associated weapons systems. Large areas also enhance realistic tactical training by providing additional airspace for adversary aircraft to evasively maneuver to possibly avoid F-16 radar detection. Pilots at Hill AFB having experience with the F-16 feel that there should be at least one horizontal dimension allowing adversaries in simulated combat a distance of 40 to 50 miles between them. In addition, a large area for supersonic training is highly desirable because when the aircraft operates over a large geographic area, the booms would be widely dispersed. Consequently, the number of booms perceived by any single area location would be significantly reduced.

(5) Operational altitudes available for the area must be low enough to accommodate realistic training but not so low as to conflict with effective air route traffic control and general aviation traffic. In addition, since ground sonic boom effects are inversely proportional to the altitude of the aircraft above the ground, the minimum operational altitudes must be a compromise to allow realistic training while minimizing the sonic boom effects on the public beneath and adjacent to the airspace.

2.2.2.2 Training Areas Evaluated for Supersonic Flight:

The only airspaces available as alternatives for the proposed action are those MOA's and restricted airspaces making up the Utah Test and Training Range as shown in Figure 1.0. Because of Hill Air Force Base's geographic location, establishing a new airspace as a supersonic flight MOA was not considered as a potential alternative. Areas north and south of Hill are relatively high population areas and to the east are mountain ranges which are not only heavier populated than the areas around the UTTR, but are generally considered of more recreational value than the desert areas to the west. These land use restraints plus conflicts with commercial airways limit the area of study to the desert regions west and southwest of the Great Salt Lake and Hill AFB. It should be noted that the combination of the Gandy Range Extension and the smaller adjacent restricted airspace, considered to be the best choice for the supersonic airspace, is located outside the optimum 100 nautical mile range. However, it is close enough that this was determined to be an acceptable trade-off when compared to the considerations presented by other alternatives.

2.2.2.2.1 Lucin Military Operations Areas (West and North of R-6404): The Lucin MOA's are located in the northern end of the UTTR as shown in Figure 1.0. This area fits the 100 nautical mile criteria better than the Gandy Range but is less acceptable according to the other selection criteria.

This area is transited by several commercial airways and to avoid these airways the supersonic flight airspace would be severely restricted in size and therefore usage. Although the land area under this airspace is definitely rural in nature (portions directly west of R-6404 consist of Salt Flats), the areas above the desert flats probably have higher population densities than land areas below the Gandy airspace. Besides numerous farms and ranches, this area includes the communities of Montello, Lucin, Etna, Cobre, Grouse Creek, Rosetta and Park Valley. Amoung these, the only towns listed with a population in either the 1982 Rand-McNally Commercial Atlas or the 1980 US Department of Commence Census, were Montello with 180, Cobre with 10, Grouse Creek with 105, and Park Valley with 35. Certain land areas beneath this MOA have already proven to be very sensitive to the noise created by existing low level aircraft activity. In the past several years, there have been noise complaints centering out of the Montello, Nevada and Park Valley, Utah areas. There has even been alleged damage to chicken ranching reported from the Montello area. Also, pilots stationed at Hill generally feel the topography of this area does not lend itself to air combat maneuvers as well as does Gandy. Pilots will occasionally use mountains or mountain ranges for "masking" purposes before the actual air-to-air intercepts occur. Also, this airspace is not as appropriate as the proposed airspace for intercepting flights staging out of Michaels Army Air Field at Dugway or out of Nellis AFB at Las Vegas. In addition, none of this airspace can make use of the elaborate tracking equipment which will make up the HUS Arena described in section 1.1.2. Even the Gandy Range is not totally within the HUS Arena, but because a good portion of it is, more of the Arena can be used to its fullest capability. Also, with all of the proposed airspace being in or adjacent to the Arena, the Arena can be scheduled heavier because overflow can be handled in airspace that does not require additional fuel to reach. Because it is estimated that there are more residents beneath this airspace than the proposed airspace, there appears to be no significant environmental advantage to this alternative.

2.2.2.2.2 Restricted Airspace R-6404: This restricted airspace meets all the selection criteria except size. Commercial airways border the north and the south sides of this airspace and air-to-ground training tied to the DoD property below further restrict the airspace that might be used. This airspace is small to begin with; when the size is further reduced by conditional restraints it becomes unacceptable.

2.2.2.2.3 Restricted Airspaces R-6402 and R-6405: Together these airspaces meet the selection criteria; separately they become prohibitively small. However, constraints in these areas do reduce them to an unacceptable size. The western edge of R-6402 is part of the UTTR already approved for supersonic activity and would provide no additional carrying capacity. The northern portion is over DoD land operated by the U.S. Army. This portion of land contains numerous land targets as well as Michaels Army Air Field and Dugway. Usage of this land area r stricts it from consideration for supersonic flight airspace above. Also Fish Springs National Wildlife Refuge is located below the border of R-6402 and R-6405 as well as a historical Pony Express and Stage Route nich leads to Callao and which has several historical sites. Although no damage would be expected, these areas would be subjected to sonic booms under this alternative. In addition, none of this airspace can make use of the elaborate tracking equipment which make up the HUS Arena depicted in Figur 3.0. If the area of Dugway and Michaels were avoided, this alternative would appear to impact less residents, but operationally, the airspace could not take best advantage of existing facilities and would not be large enough to accommodate the daily training load.

2.2.2.2.4 Sevier Military Operations Areas: These MOAs are located east and south of R-6402 and R-6405 as shown in Figure 1.0. The narrow strip to the east is above or near several populated areas including the housing area for Dugway Proving Grounds and would be inappropriate for supersonic activity. The southeast side is not only adjacent to the populated area of Delta, Utah, but it borders heavily used commercial airways between Southern California and Salt Lake City. The bulk of these MOAs is located directly south of R-6405. Much of it is about the same distance from Hill AFB as is the outer most corner of the Gandy Range, but the southern edge is even further away. The Gandy Range is considered to be about the maximum distance away to still be practical for daily air-to-air training sorties with the F-16. Any further distance would necessitate very short air-to-air training, wing tanks for extra fuel or inflight refueling; none of which are considered desirable for daily air-to-air training. Therefore, the southern portion of the Sevier MOAs would probably be unusable for all practical purposes and the airspace available would be cut in size.

Another advantage Gandy has over the Sevier MOAs is that approximately twice per week a KC-135 refueling tanker is available in the area of R-6406/6407. These tankers provide inflight refueling training and can be used to extend training times. This capability would be particularly beneficial to the two seater version of the F-16 that does not have the fuel capacity and range of the single seater. The refueling track lies close enough to the proposed supersonic flight airspace that both types of training (refueling and air combat maneuvering) can be accomplished in the same sortie going there. Joint usage would be difficult with sorties going to the Sevier MOAs.

2.2.3 Use of Distant Supersonic Flight Airspaces:

Since there are a number of locations within the United States where supersonic flight training is conducted by other units, one option considered was joint use of that airspace by the 388 TFW and the managing unit. The closest such airspace to Hill AFB is the Nellis AFB Range Complex which is located north of Las Vegas, Nevada, approximately 320 miles southwest of Hill AFB. Due to the distance from Hill, the most practical alternative for utilization of this airspace would involve deploying a unit to Nellis AFB for supersonic flight training. Before examining the advantages and the disadvantages of a satellite operating location, the availability of area time for Hill usage of the Nellis Range complex must first be considered. The Nellis range airspace is used extensively to support mission training requirements of combat ready flying units permanently stationed at Nellis AFB.

Additionally, because the airspace is large, supersonic flight certified, and has minimum operation restrictions, it provides invaluable tactical training for aircrews participating in Tactical Air Command Exercise Red Flag. This on-going training exercise allows combat ready pilots from units located throughout the United States to periodically deploy to Nellis AFB and practice, evaluate and refine combat tactics in a simulated, but very realistic, wartime environment. The continual scheduling demand for Nellis range airspace by the Red Flag training exercise and the flying units stationed at Nellis results in near 100% usage of the areas during the daylight hours. Although 388 TFW pilots use the airspace on a short-term basis while participating in the Red Flag exercise, any long-term shared use of the areas is not considered feasible due to existing airspace usage, travel cost and expense to support a satellite operation. If adequate shared use time was available on the Nellis Range complex, the costs associated with temporarily deploying squadrons there for supersonic training would be substantial.

Other supersonic flight airspaces are located at various places in the United States. Temporary deployment of portions of the 388 TFW to these locations would improve supersonic flight training capability, but the operational practicality and cost effectiveness of such an alternative are questionable for the following reasons. To avoid the prohibitive expense of maintaining a complete on-site parts inventory, replacement aircraft parts would be maintained at Hill and transported to the operating location when required. In addition to increased transportation cost, the time delay in getting parts from Hill would reduce aircraft in commission rates at the operating location. With a portion of the wing deployed away from Hill on a long-term basis, the wing's quick reaction deployment posture would be seriously degraded. In the event the wing was tasked to mobilize for rapid worldwide deployment, critical time would be lost by not having a significant portion of the wing resources at home and immediately available.

The adverse impact on the moral of Air Force personnel required to support this alternative is another factor which must be considered. While deployed to the operating base, families of operations and maintenance personnel would have to remain at Hill. The necessity for family separation is accepted in the military; however, the validity of forced family separation to accomplish supersonic flight training at a satellite location when that training could be reasonably accomplished in areas nearby Hill would be seriously questioned. If the alternative was implemented, to lessen the resulting family separation impact, the deployed portion from Hill would probably rotate personnel to serve a maximum of 60 days at the temporary operating basis. An additional factor relating to satellite base operations must be considered. Deployed operations would increase the number of takeoffs and landings at the satellite operating base, resulting in an increased noise impact on populated areas near the base.

Utilizing distant supersonic flight areas would require either inflight refueling or temporary deployment to a satellite operating base. Inflight refueling could extend the distance traveled per sortie, but because of the number of sorties involved per day, several refueling aircraft would be required. Additional fuel consumed by the F-16's and the refueling aircraft would be significant especially in this era of high fuel costs and low fuel availability. Deployment of aircraft to a satellite operating base would involve the temporary relocation of a significant number of pilots and maintenance personnel on a rotating basis. This would also be at great additional expense to the Government. Although to some degree practical for short-term operations, on a long-term basis, shared use of distant supersonic areas in lieu of establishing local supersonic flight areas is cost prohibitive and detrimental to the overall accomplishment of the Air Force mission.

2.2.4 Relocate the 388 TFW:

In the environmental evaluation for the beddown of the F-16 aircraft at Hill AFB, 89 bases were evaluated as alternative locations. Hill was considered to be the optimum location for the F-16 aircraft beddown based on the following criteria:

(1) Suitable air-to-air/air-to-ground ranges located in close proximity.

(2) Availability of supersonic flight airspace over sparsely populated areas.

(3) Beddown without relocation of existing mission/missions. To avoid excessive facility and relocation costs, the beddown of a weapons systems should avoid the requirement for a double move or locating two wings on one base.

(4) Existing base support facilities requiring only limited new construction to accommodate F-16 training/operational requirements.

(5) Minimum adverse environmental impact. A beddown site should be selected which keeps adverse impacts on the environment to a minimum. Air and noise pollution, urbanization of the area around the base, civil and general traffic and the capability of the base and surrounding communities to accept a change in population are factors considered.

It is the Air Force's contention that Hill AFB is still the optimum location for the 388 TFW and its F-16 aircraft. The economics have now shifted even more in favor of Hill since facility construction and modification have already taken place to accommodate the F-16 mission. Although the construction and modification cost about $10 million, the 388 TFW is now assigned about 617,000 square feet of facility space at Hill that has an inventory value in excess of $35 million. It is unlikely that any other installation could meet this type facility requirement without starting a chain reaction of existing mission relocations.

Relocating the 388 TFW would also have an adverse impact on the economy of the Hill AFB vicinity. As of March 1983 the 388 TFW had an annual payroll in excess of $47 million. Although this payroll goes almost entirely to military personnel, a sizeable portion of it can be expected to filter into the area economy. Relocating the 388 TFW without a similar replacement mission would leave a noticeable gap in various market places such as housing and retail stores around Hill AFB.

2.2.5 Change the Geographic or Vertical Limits of the Proposed Supersonic Flight Airspaces:

An alternative to be evaluated is changing the area boundaries or vertical working altitudes so that certain ground locations are removed from supersonic overflight. The following paragraphs address the ramifications of geographic area boundary and vertical altitude changes.

2.2.5.1 Geographic Boundary Changes:

The first option in terms of area boundary change involves increasing the size of the area so as to disperse the effects of sonic boom activity over a larger area. Although this would expose more people to the sonic boom activity, any specific location should encounter fewer sonic booms due to the dispersion. No area expansion is possible to the north because of the town of Wendover and existing commercial airways. Any expansion to the south would encompass the Mount Moriah area (identified as a sensitive area in section 4.3.2) and would put the supersonic flight airspace closer to the community of Baker plus putting more of the area further away from the optimum 100 nautical miles from Hill AFB. Expansion to the west appears feasible, but again, this would be expanding the airspace in a direction further from Hill AFB and it would place supersonic flight activity closer to the communities of Currie, McGill, and Ely. The area to the east of the north end of the proposed airspace is already airspace approved for supersonic flight. The remaining airspace to the east is already airspace restricted for military usage and has been addressed in the section discussing alternate locations.

The second geographic change option would be to reduce the size of the area so as to remove certain populated areas from the supersonic flight training area. Imposing area restrictions is preferable over a complete relocation of the area boundaries so that existing airspace, although for subsonic speeds, remains useable. However, the land area involved is so rural in nature that it would be difficult to find any areas of concentrated population to avoid. The place where the largest portion of the area's population is known to exist is the Goshute Indian Reservation which surrounds the community of Goshute. Even here, the population appears to be distributed throughout the reservation. Because it is located adjacent to mountains, the town of Goshute is not beneath one of the supersonic activity ellipses described in section 4.1.2.2.1 and shown in Figure 8.0. However, the northwestern boundary of the Reservation is beneath the middle ellipse.

If a 5 or 10 mile supersonic flight restriction were placed around the Goshute Indian Reservation, the frequency of sonic booms perceived within that area would be reduced. This option would, however, severely restrict the F-16 operational training capabilities in the area since it would make it unrealistic to operate over the Antelope Valley and still maintain an appropriate working distance from the area at the north end of the Gandy Range Extension. The training airspace over Antelope Valley will be located as far north as possible but, because of the working distance requirements, the northwestern portion of the Goshute Indian Reservation will probably be impacted by the noise from sonic booms. To decrease the amount of airspace available in this central portion of the Gandy MOA would preclude the realistic deployment of the F-16 weapons system there. In addition, if the supersonic flight training area size was reduced in this manner, the people located beneath the remaining sections of the area could expect increased sonic boom activity.

2.2.5.2 Vertical Altitude Changes:

The perceived effects of sonic booms are directly related to the altitude of the supersonic aircraft. As the aircraft's altitude above the ground increases, the resulting sonic boom noise and overpressure effects decrease. The higher the minimum altitude, the less impact supersonic flight will have on the public beneath the airspace. This relationship along with the training requirements of the F-16 were considered in establishing the minimum operating altitude at 5,000 feet AGL. The training scenario for F-16 air-to-air combat maneuvers calls for a floor of 5,000 feet AGL. This gives the aircraft an adequate safety buffer from the ground but still allows the aircraft to fly at elevations where experience is required for realistic training. It is estimated that most sonic booms will be created at about 15,000 feet AGL. If the airspace below this level was significantly restricted more than by the 5,000 foot minimum, pilots would be forced to employ the aircraft in higher altitude regimes where low air density causes reduced engine/airframe efficiency and decreases the maximum performance of the aircraft. Although operation at altitudes above 30,000 feet MSL is tactically sound during the initial intercept phase, as the engagement progresses into a three dimensional "dog fight" all participants must decrease altitude to utilize the maximum acceleration and turning performance of their aircraft.

2.2.6 Summary:

No action to increase the quantity of supersonic flight airspace will restrict realistic training and the wartime effectiveness and survivability of F-16 aircrews cannot be optimized. Due to high priority national research and development projects, special exercises and F-16 air-to-ground training, the existing UTTR supersonic flight airspace will frequently be unable to accommodate the 388 TFWs F-16 air-to-air sorties. Existing restricted airspaces or MOAs making up the UTTR or new areas within 100 nautical miles of Hill AFB are not considered feasible alternatives for supersonic flight training. As compared to the proposed airspace, alternatives for supersonic flight training areas would result in a negative impact on existing military usage, commercial/general aviation traffic and/or would expose significantly more people to sonic boom activity.

The capability of sharing supersonic flight airspace managed by other units is limited by the transite distance required to obtain this training. Excluding the UTTR, the nearest supersonic flight airspace is 320 miles from Hill. To obtain the same area training time per sortie, as do sorties to the Gandy area (23 minutes), costly inflight refueling and long F-16 transit operation would be necessary to support this alternative.

The costs, degraded quick reaction deployment posture, and operating limitations resulting from deploying a squadron to a satellite location for shared use supersonic flight training are unattractive when compared to local operations within the proposed supersonic flight airspace.

Because of the operational and environmental suitability of the proposed airspace, it appears that supersonic flight training would impact that area the least of any area considered. Relocation of the 388 TFW is considered impractical because of the desirable attributes of the Hill location and the excessive costs required to move and set up operations at another base, aside from the economic impact on the local community.

Changing the geographic or vertical dimensions of the proposed supersonic flight airspace would severely restrict F-15 realistic training opportunities in this area. If the geographic size was reduced, the public beneath the adjusted area boundaries would be exposed to more concentrated sonic boom activity as a result of the smaller operating airspace. Raising the minimum supersonic flight altitude above 5,000 feet AGL would degrade realistic air combat training in the area. If the floor of the airspace were raised an additional 5,000 feet or more, training would be seriously degraded because it would have to be accomplished at altitudes that would not represent actual combat situations. If the floor were raised to somewhere between 5,000 and 10,000 feet AGL, training would suffer because the lower altitudes were not available as a buffer.

The alternatives that will receive additional consideration in section 4 include no action, other airspaces within the UTTR and vertical dimension changes to the proposed airspace. The other alternatives identified in this section are considered to be either economically impractical or too degrading to the 388 TFW's deployment posture to receive additional attention.

## III. AFFECTED ENVIRONMENT:

### 3.0 General:

The proposed supersonic flight training airspace overlies western portions of Tooele, Juab and Millard Counties in Utah and eastern portions of Elko and White Pine Counties in Nevada. Its horizontal limits are the same as those of the existing Gandy MOA/ATCAAA plus the space between the Gandy MOA/ATCAAA and the existing southern supersonic flight airspace to the east. Refer to Figure 6.0 for specific county boundaries beneath the airspce. The majority (estimated at 70 to 80 percent) of the land area beneath the proposed supersonic flight airspace is public and under the jurdisdiction of the Bureau of Land Management. The exceptions to this are the Goshute Indian Reservation, small scattered parcels of private land and those state lands acquired from Congress for the development or benefit of state institutions.

### 3.1 Existing Site Characteristics:

#### 3.1.1 Population:

The area is very sparsely populated, with an estimated total of less than 350 people residing within the boundaries. Maps of the area beneath the proposed supersonic flight airspace show the towns or communities of Goshute, Trout Creek, Partoun, Gandy, Ibapah and Gold Hill in Utah, and Tippett and Uvada in Nevada. The only towns listed with a population in either the 1982 Rand-McNally Commercial Atlas or the 1980 U.S. Department of Commerce Census were Trout Creek with a population of 15 and Iabpah with a population of 25. Tippett and Uvada were listed but were identified as rural areas with no populations given. Neither reference had populations for Goshute nor the Goshute Indian Reservation; however, Utah's Indian Affairs office estimates the Reservation population at about 150 people. There are scattered ranches in the area beneath the airspace, primarily in the southern portion, but none of the populated areas are considered more than rural. The towns of McGill (population 1,900), Currie (population unlisted), Wendover (population 1,099), Callao (population 19), and Baker (population 50) are located outside of the area boundaries (see Figure 6.0).

#### 3.1.2 Topography:

The land area below the proposed supersonic flight airspace is located in a area of the Western United States often referred to as the "Great Basin" which is within the site of the ancient Lake Bonneville. As part of this basin, it resembles most of the other parts of Nevada and Western Utah in having high mountain ranges running north and south, cut by narrow valleys. There are no large bodies of water in the area beneath the airspace; the water system being confined to mountain streams and small lakes. The ranges and valleys within the area are shown in Figure 7.0. The largest valleys are Antelope Valley and Deep Creek Valley. The area also contains the Goshute Mountains, the Antelope Mountain Range and the Deep Creek Mountains. The highest mountains in the area belong to the Deep Creek Range rising 7,800 feet above the Great Salt Lake Desert on the east to a

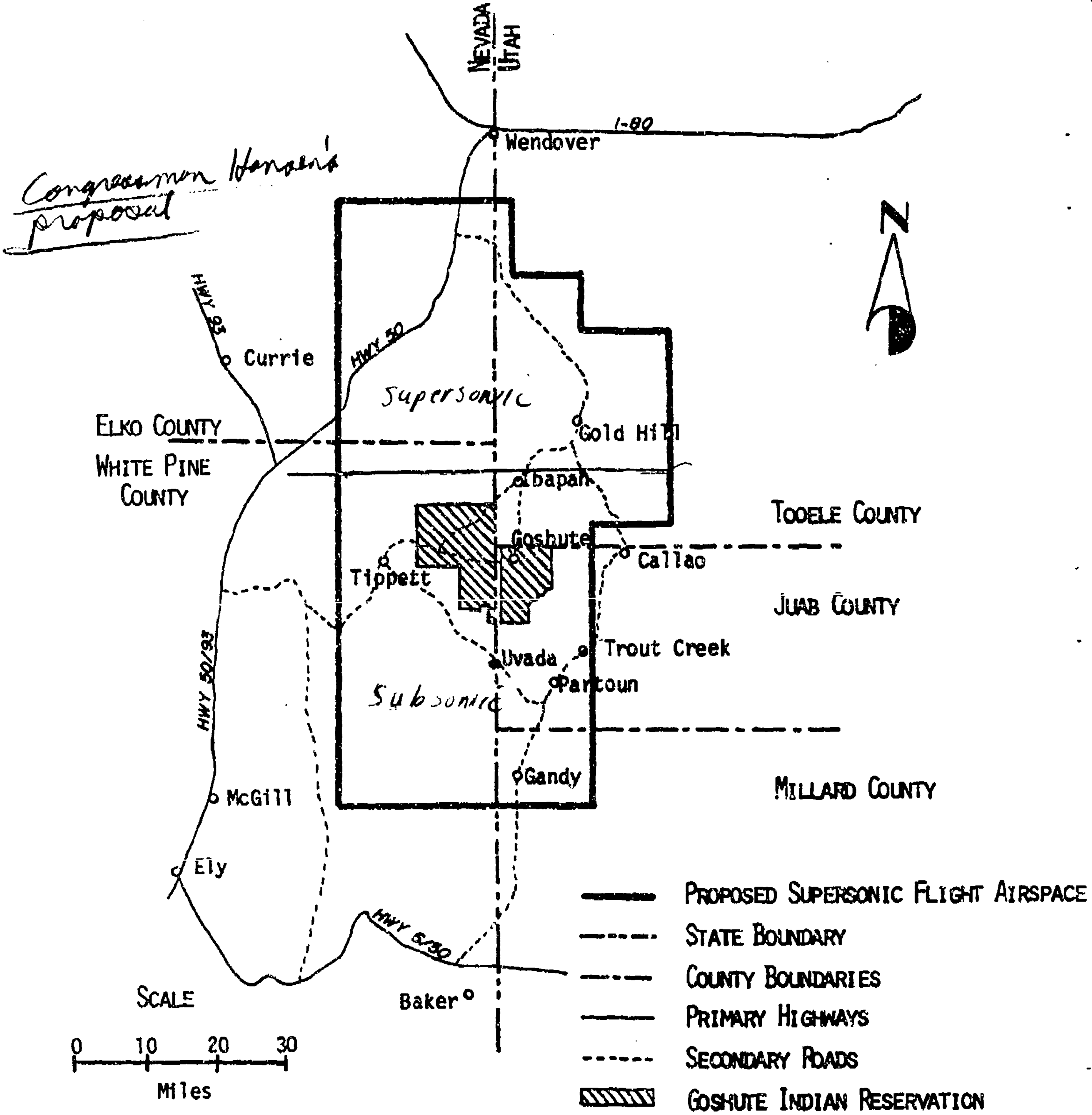



Figure 6,0
Towns in the Vicinity
of the Proposed Airspace

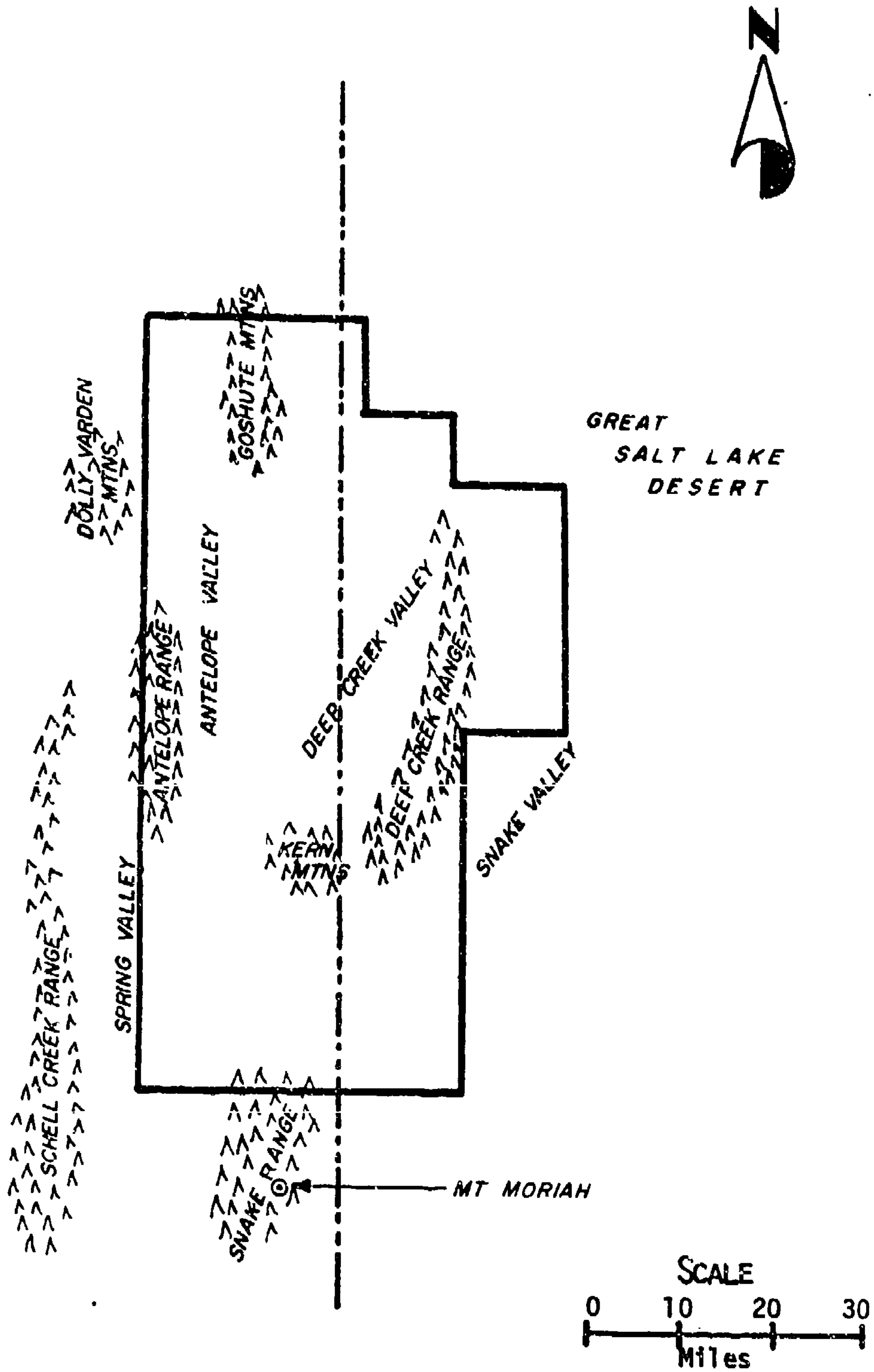



FIGURE 7.0
RANGES AND VALLEYS
IN THE VICINITY

maximum of 12,109 feet MSL on Ibapah peak. Most of the area's population is in valleys that vary in elevation from about 5,000 to 6,000 feet MSL. The entire area is considered arid; however, because of their height, the Deep Creek Mountains catch many of the storm clouds moved by the prevailing winds from the west and cause them to drop moisture on the western slopes. As a result, Deep Creek Valley is better watered than most valleys in Nevada.[22] Several mountain streams flow down to form Deep Creek and there are many miles of natural wild grass meadows. This is the first fertile valley west of the great salt flats, and is somewhat of an oasis even though still being considered an arid valley.

### 3.1.3 Vegatation:

The valleys are covered with typical desert shrubs, greasewood, sagebrush and scattered grasses which, in some instances, are suitable for grazing. In the area of the Deep Creek Range, because of increased altitude and precipitation, the valley vegetation gives way to the pygmy forest community (juniper and pinyon pines) on the higher slopes and the subalpine community (pine, spruces and quaking aspens) in the summit area. Other mountain ranges have similar vegetation sequences but most other areas do not reach the subalpine community because of lower elevation and less precipitation.[31]

### 3.1.4 Animals:

3.1.4.1 General: Sheep are the predominant domestic animals inhabiting the area with beef cattle and horses also present in some areas. Wildlife in the area includes not only small mammals and reptiles, but also antelope, mule deer, bobcats, mountain lions and other carnivore ranging from coyotes to ermine. Additionally, sightings of numerous raptors and other avain species have been documented, including observations of high densities of golden eagles year-round. This area is also winter habitat for bald eagles. Information now being accumulated on raptors indicates the area around the Utah-Nevada border may be within the migratory pattern of several types of raptors.

3.1.4.2 Threatened and Endangered Species:

The Utah Division of Wildlife Resources (DWR) has identified two endangered species as occurring within a 50 mile radius of Hill AFB and the Utah Test and Training Range; the peregrine falcon and the bald eagle. The Elko (Nevada) District Office of the Bureau of Land Management (BLM) identified four animals as occurring on the Nevada side of the Utah Test and Training Range and on the threatened and endangered species list: the peregrine falcon, the bald eagle, the spotted bat and the stepdoe dace. Although difficult to identify the exact population size and extent of these species, it appears that of the four, only the bald eagle frequents the area of the proposed supersonic flight airspace.

1. American Peregrine Falcon (Falcon peregrinum anatum): Nesting apparently occurs throughout northern Utah. Habitat consists primarily of cliffs and rock bluffs, below 3,000 feet elevation, and in proximity of a significant body of water. According to a 7 December 1977 letter from the DWR, there have been five documented sightings of the peregrine falcon in

the area of northern Utah since passage of the Endangered Species Act of 1973. The letter also identified five historic eyries occurring within this area and two candidate parcels of "critical habitat," designated as such for possible reintroduction of natural reoccupation by wild stock. None of the locations identified in sightings, as historic eyries or as critical habitat are within the subject airspace. However, one of the historic eyries is in the area of Wendover, immediately north of the proposed airspace. In more recent conversations (September 1982), the DWR has indicated that there have been no recent documented sitings of the peregrine falcon in the UTTR area.

2. Southern Bald Eagle (Haliaeetus leucocephalus): Year-long habitat is restricted to the Goshute Mountain Range and to several areas west of the area of interest. Winter habitat in Nevada listed as crucial to this bird occurs at the south end of the Goshutes and in the Dolly Varden Mountains to the west. Each winter large numbers of bald eagles spend a portion of their annual life cycle in Utah. Little use is made of the relatively barren west desert of Utah which is in a 50 mile radius of Air Force Range areas. However, there are published accounts of significant numbers of bald eagles occurring in the area of Vernon, Utah, which is about 62 miles east of the proposed supersonic flight airspace and there have also been sightings within Range boundaries, by Air Force personnel and by State and Federal wildlife specialists.

3. Spotted Bat (Euderma maculatum): This bat is not on the federal list but the states of Nevada and Utah are interested in it because it occurs in a limited range. The limiting factor on the distribution of this species is thought to be food, as it feeds exclusively on small moths. Areas of distribution have not been well defined, but are thought to include the country around Wendover.

4. Steptoe Dace (Relictus solitarius): This fish is found in waters that were tributaries to the ancient Bonneville Lake. There are 12 known sites in Nevada that presently support populations of this fish; the closest to the Utah Tes., and Training Range area being Big Springs Ranch in Goshute Valley which is northwest of the existing Gandy Range Extension.

3.1.5 Land Use:

3.1.5.1 Grazing: Several of the valley areas below the proposed airspace have been used historically for grazing purposes. The story of the Deep Creek Valley is similar to many areas in the west, where cattle first dominated the range lands. Then the cattle empires were cut down by fencing of the range lands and sheep ranching. Sheep then dominated the valley until the early 1900's. The Taylor Grazing Act cut many large sheep ranches down to small ones and small ranches were put out of business. Now much of the grazing land is under the control of the BLM.

The BLM controls grazing on public land by issuing grazing permits for cattle and sheep. The maximum loading for the land under the airspace varies accordi.g to area and season of the year. The loading rate ranges from 1 cow per square mile in the summer months to 7 cows per square mile in the wetter winter months. Present actual usage is about half the maximum potential, about 7700 head of cattle and 24,000 head of sheep. These figures are based on BLM grazing permit information with about 5 sheep equaling 1 cow for grazing loads.

3.1.5.2 Agriculture: Because of the arid nature of this area, agriculture has not been an important land use. Any agricultural usages are very small in nature, located in conjunction with and generally for consumption by the isolated residents of the area.

3.1.5.3 Mining: The mineralization of the area is related broadly to that of the Basin and Range. The general area is considered to be a possible source of tungsten, lead, silver and gold. Historically, the Deep Creek Range has been an area of significant mining and exploration consideration, being a potential producer of gold, silver, lead, copper, tungsten, beryllium and mercury.[31] However, mining operations throughout the area are isolated and small in scale.

3.1.5.4 Recreation: Recreational activities in the area are limited for the most part, to those activities taking advantage of its unspoiled nature. These activities include hunting, hiking, horse riding, camping, nature study, etc. However, because of the remoteness of the area, the number of people participating in these activities are relatively small. The BLM has estimated that recreational usage of the Deep Creek Mountains, in both Juab and Tooele Counties of Utah, amounts to 6,000 vists per year totaling some 22,000 visitor hours. These visits included hunting, fishing, hiking and camping activities. It is also estimated that the Pony Express Trail draws some 150,000 visits per year involving 1.2 million visitor hours. These recreational visits include primarily camping and recreational vehicle (RV) activities; in fact, the more readily accessable portions (closest to populous areas) are outside the impact area.

3.1.5.5. Tourism: There is only one major road through the area; U.S. Highway Alternate 50 which heads southwesterly across the area from Wendover to Ely. Other roads in the area are primarily for access to specific locations and may lend themselves to the recreational activities described above, but probably would not be considered suitable for tourism as they do not provide facilities.

## 3.2 Socio-Economic Conditions:

The economy of the area depends almost entirely on ranching and the small amount of mining that takes place. Due to the low annual rainfall and relatively arid conditions, the water supply is critical to the economy and the type activities that the area can support. For the most part, areas where people are located are determined by the available water.

## IV. ENVIRONMENTAL CONSEQUENCES:

### 4.0 General:

This section provides the environmental consequences associated with the proposed action and those alternatives warranting additional discussion. The environmental consequences addressed in this section are found to be generally acceptable for residential living, and the specific training sites identified later within the proposed airspace will generally avoid areas of known population. Basically, the proposed supersonic flight airspace meets operational requirements better than the alternate sites and does not present a significantly different environmental impact.

### 4.1 Environmental Impacts of the Proposed Action:

#### 4.1.1 Air Quality:

The proposed supersonic flight airspace overlays portions of Elko and White Pine Counties in Nevada and Millard, Juab and Tooele Counties in Utah. In the EPA review of state Air Quality Control Regions, the concentrations of particulate matter and of sulfur oxides throughout the area, with the exception of Tooele County in Utah, were listed as being "Better Than National Standards". Tooele County in Utah is listed as exceeding primary and secondary standards for sulfur oxides. However, these violations are due primarily to smelting operations on the eastern side of the County, some 90 miles east of the airspace. The concentration of oxidant (ozone) is listed as being "Better Than National Standards" in Nevada. Due to sparse population and lack of ambient air quality monitoring data, EPA considers the entire area to be "Better Than or Cannot Be Classified" in respect to attainment of the carbon monoxide and nitrogen oxide standards and also for the ozone standard in the Utah portion of the area. The airspace is not located in an Air Quality Maintenance Area.

Military aircraft conducting flight training operations within the proposed airspace will emit air pollution contaminants of particulate matter, hydrocarbons, carbon monoxide and oxides of sulfur and nitrogen. Table 2.0 provides an estimate of the projected annual pollutant emissions from the proposed air-to-air training operations within the proposed supersonic flight airspace. The quantity of each pollution was derived using data for F-16 pollutant emission rates obtained by Air Force testing and the projected annual hours of flying activity in the airspace assuming each sortie lasts 23 minutes. Sorties going into this airspace are normally scheduled for 30 minute blocks, but because of this airspace's distance from Hill AFB and the associated fuel constraints, 388 TFW pilots estimate that each sortie will last from 15 to 30 minutes (hence the 23 minute estimate). Local pilots also estimate that afterburners are used for an accumulated time of 2.5 to 3 minutes during the training sortie. Therefore, for the purpose of estimating air pollutant emissions, it will be assumed that each air-to-air sortie in this airspace will involve 20 minutes at military power settings and 3 minutes at afterburner. It should be noted that individual afterburner bu sts last only frcm 15 to 30 seconds in order to conserve fuel. (The most advantageous use of fuel is a part of a pilots training.) Sometimes these short afterburner bursts, used for combat maneuvers, take the aircraft to supersonic speeds and sometimes they do not. As mentioned previously, from observing similar operations, the Air Force estimates the speed of sound will be exceeded between 2 and 3 times during such a sortie.

TABLE 2.0

PROJECTED ANNUAL EMISSIONS
FROM F-16 AIR-TO-AIR SORTIES

| Pollutant | Emissions (Tons/Year) |
|---|---|
| CO | 86.2 |
| HC | 2.6 |
| $NO_x$ | 702.1 |
| $SO_x$ | 80.6 |
| Particulate (Total) | 10.6 |

These pollutants will be emitted over a large area (portions of 5 counties, roughly 3,030 square miles) and at an elevation normally ranging from 10,000 to 20,000 feet AGL. All training operations involving supersonic speeds within the proposed supersonic flight airspace will be conducted above 5,000 feet AGL. If the proposed supersonic airspace is not approved, it should be noted that there would possibly be as many as 500 subsonic flight sorties in this area per month. (Without the supersonic flight airspace, this area will still have to accommodate many of the air-to-air sorties.) Therefore, roughly half of the emissions shown in Table 2.0 would still be emitted within the airspace and possibly with more at lower elevations. The Environmental Protection Agency[35] shows the area's mean annual morning and afternoon mixing heights to be about 1000 feet and 6900 to 7900 feet AGL, respectively. The mixing height is the height above the surface through which relatively vigorous vertical mixing occurs. The mean annual wind speed averaged through the morning and afternoon mixing heights are 9 and 13 miles per hour, respectively.

All supersonic activity will take place above 5,000 feet AGL and, therefore, well above the mean annual morning mixing height. It is also estimated that 90 to 95 percent of the supersonic activity will take place above 10,000 feet AGL and will also be above the mean annual afternoon mixing height. That pollution which is emitted within the mixing height should not create a significant negative impact because the area has good dispersion characteristics. Some dispersion will also occur as a result of the turbulent wake behind the aircraft. Those pollutants emitted above the mixing height will remain aloft until the mixing height exceeds the altitude in which the pollutants were emitted. By this time the pollutants probably will have traveled a great distance (some times hundreds of miles) and would be greatly diluted before being returned to ground level. Considering the amount of pollutants shown in Table 2.0, it is not expected that the quantity of those pollutants returning to ground level would change ambient air quality in the area or in any other air quality control region.

4.1.2 Noise Impacts:

4.1.2.1 General:

Noise in the area will result from two sources: First from the aircraft itself, and then from the phenomenon produced when an aircraft exceeds the speed of sound and causes a sonic boom. The aircraft in flight produces sound from two sources: engine noise and airframe noise as the aircraft moves through the air. When the aircraft is at subsonic speeds (less than the speed of sound), the noise levels will be insignificant. As an example, if all 40/50 sorties per day were to pass directly over the same spot at 10,000 feet above the ground (a very unlikely worst case) the day-night average sound level (DNA) would be 43.4/44.3 dB. DNL is an equivalent sound level over a 24-hour period that is equal, on an energy basis, to the fluctuating noise signal under consideration (aircraft overflights) with a 10 decibel penalty added to any sounds that occur in the night. By convention, A-weighted sound exposure levels are used to calculate the DNL values. A DNL of 40 to 47 is the typical range of noise levels for a rural community. Day-night average sound levels below 55 decibels are considered by the Environmental Protection Agency[36] to have no effect on public health and welfare, and sound levels below 65 decibels are completely acceptable for residential purposes by the Department of Housing and Urban Development.[37]

At the present time, subsonic operations occurring within the proposed supersonic flight airspace include special test operations and their support aircraft, intercepts, ingress and egress flights to and from ground targets on DoD land, refueling operations, Red Flag exercises, and others. These operations often take place at elevations below the normal air-to-air combat maneuvers and sometimes below 5,000 feet AGL. Despite sometimes having lower elevations, these operations are so widely dispersed throughout the Gandy airspace that the DNL created at any one location on the ground would be small. Even if the example in the preceeding paragraph were doubled to account for these existing operations, the DNL figures would only increase by 3 dB. The Public Affairs Office at Hill AFB logs and monitors all noise complaints that are received because of Air Force operations in the vicinity. They are unaware of any history of noise complaints coming from the land areas beneath the airspace under consideration.

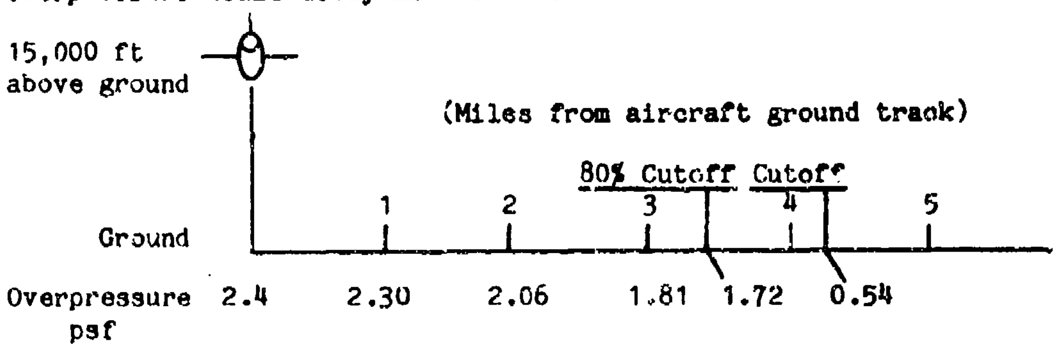
If approved for supersonic flight, aircraft involved in air-to-air training in the airspace will be at subsonic speeds during most of their flight, but will accelerate to supersonic flight when conducting basic fighter maneuvers. In order to accelerate to supersonic airspeeds, the F-16 will use the afterburner (thrust augmentation) prior to going supersonic. Afterburner light-off results in a rapid increase of the sound level and is occasionally misinterpreted as a sonic boom.

An important consideration in the assessment of the effects of sonic booms is that not all booms created are heard at ground level. The atmospheric air temperature decreases with height above ground. This temperature gradient acts to bend the sound waves of a sonic boom upwards. Depending upon the aircraft height and Mach number, the paths of many sonic booms are bent upward sufficiently that the boom never reaches ground level. The heights and Mach numbers produced during F-16 combat maneuvering are such that less than one boom out of every three produced is likely to be heard at ground level. This same phenomenon also acts to limit the width of those sonic booms that do reach ground level. This concept of sonic boom "cut off" is discussed more fully in Appendix B.

4.1.2.2 Supersonic Noise (Sonic Booms):

When aircraft exceed the speed of sound, or Mach 1 as the airspeed is referred to, a particular phenomenon occurs that is heard by individuals within a defined range as a sonic boom. The boom is an instantaneous sound similar to a thunder clap or a rifle shot. The noise levels and the related parameter "overpressure" vary significantly depending on where and how a boom is generated. The overpressure is basically a function of the distance of the aircraft from the observer, the shape of the aircraft, and the airspeed of the aircraft. The maximum overpressures normally occur directly under the flight track of the aircraft and decrease as the slant range from the aircraft to the observer increases. Because of the normal temperature gradients in the atmosphere, the sonic boom waves tend to refract or bend upward as they move away from the aircraft until at some point out to the side of the flight path they no longer reach the ground. This horizontal distance at which the waves no longer touch the ground is called the cutoff distance. The sonic boom wave overpressures decrease at a rate proportional to the -(3/4) power of the slant range between the aircraft and the observer until they reach a distance approximately equal to 80 percent of the cutoff distance. From here to cutoff, the wave disintegrates more rapidly. This phenomenon is described in more detail in Appendix B.

As an example, if an F-16 aircraft flying at supersonic speed and at 15,000 feet above the ground produced a sonic boom that generated an overpressure of 2.4 pounds per square foot (psf) directly beneath the aircraft, the overpressure would decay as shown below:



Knowledge of sonic booms produced in steady rectilinear flight is sufficient to allow for good predictions of the phenomena. The effects of turns and maneuvers during supersonic flight have been studied by the French during exercise Jericho. The study was an intensive investigation into the "focus" phenomenon. A focus boom occurs when shock waves from an aircraft in supersonic flight converge on the same point in space at the same time. The point of convergence can occur either on the ground or at some point in the atmosphere. The focus boom occurs only at a specific location and does not move as the aircraft moves. Estimates of the intensified overpressures occuring as a result of focusing range from two to five times the peak nominal overpressure.[36]

Aircraft in supersonic flight are most likely to produce focus booms that may reach the ground while performing three particular maneuvers: linear accelerations, turns and pushovers. Other maneuvers such as pull ups, decelerations, large radius turns, and small curvatures of the flight path do not generate focus booms. Focus booms are discussed in more detail in Appendix B. In one Air Force test on fighter aircraft, 205 sonic booms were produced, of which 18 caused booms reported by residents. From the evaluation of this test data, it was Galloway's (41) subjective opinion that one of these booms could have been a focus boom. The Air Force, along with other DoD services, is involved in efforts to model the situation to determine where and in what situations focus booms will be generated. More information on these efforts and their findings should be available for inclusion in the final version of this document.

Aircraft operating at supersonic speeds will also produce shock waves that travel in the atmosphere above the aircraft. When these waves hit the region of the atmosphere where temperature increases as altitude increases (the inverse condition to what normally occurs at lower altitudes) they are refracted back toward earth. Shock waves created below the aircraft that bounce off the ground or which refract upwards before reaching the earth, will eventually go back to earth in a similar fashion. These type shock waves form a secondary boom carpet at ground that lies outside the primary carpet. However, they create very minor overpressures (on the order of 0.001 to 0.01 psf) and have not been associated with any significant community response or adverse impact. This phenomenon of a secondary boom carpet is discussed further in Appendix B, but it is not discussed further as a potential adverse environmental impact.

Sonic booms and their effects have been studied extensively by the Air Force (AF), the Federal Aviation Administration (FAA), and the National Aeronautics and Space Administration (NASA). Appendix B contains a review of the literature in this area and discusses several tests conducted to determine sonic boom overpressure effects on people, structures and animals.

4.1.2.2.1 Sonic Boom Effects on People:

Sonic boom tests have been conducted at overpressures as great as 144 pounds per square foot. Tests conducted in 1968 at Tonopah, Nevada, reported that sonic booms with overpressures ranging from 50 psf to 144 psf do not cause injury to people. Observers positioned directly under the flight tracks of aircraft flying at less than 100 feet above ground reported some momentary discomfort, fullness and ringing of the ears during the most intense booms.[23] Although hearing acuity was not measured, subjects reported no observable symptoms of hearing loss or other ear involved disabilities. Exposure to loud sound without hearing protection will often be accompanied by a temporary ringing of the ears. The ringing acts as a warning of accoustic insult. There are dozens of other medical causes for this ringing, but when it is caused by a loud sound, it will subside after the exposure unless the exposure is too long or repeated too often. Other tests at lesser overpressures have reported that sonic booms do not cause permanent direct injury to people. The possibility of individual injury from falling objects or injury as a result of being startled by sonic booms has not been investigated. Personal injury due to indirect effects of sonic booms occur [illegible] infrequently, but the possibility of such effect cannot be eliminated.

Sonic booms in the proposed supersonic flight airspace will be generated by aircraft flying at altitudes in excess of 5,000 feet AGL with most booms being created at elevations from 10,000 to 20,000 feet AGL. The sonic boom overpressure at ground level for an F-16 at 10,000 feet AGL and Mach 1.1 airspeed (the average airspeed used during supersonic flight periods) would be expected to be about 3.51 psf. At 5,000 feet AGL, the lowest altitude to be allowed for supersonic training in the proposed airspace, an F-16 at Mach 1.1 would create an overpressure at ground level of about 6.36 psf. Although 3.52 psf and even 6.36 psf overpressure is well below that experienced during the tests in Tonopah, Nevada, that caused no physiological damage, tests conducted in both the United States and in Canada have demonstrated that a 4 psf sonic boom is considered annoying to most people. Paragraph 4.1.2.2.5 and Appendix B contain comparison tables to show maximum calculated overpressure resulting from various supersonic speeds.

The greatest impact of sonic booms on people is an annoyance factor resulting from people being startled by the boom. The annoyance factor can be caused by a variety of factors including house rattles and vibrations, interruptions of activities, sleep, conversations, television, and the like, and damage to personal property as well as the personal characteristics and psychological makeup of individuals exposed. It is also responsible for creating fear in some individuals. This fear is due to the loud, unexpected sounds that surprise the individual and is not the same as that fear associated with possible aircraft accidents. Infants, children, the elderly, etc., appear to be more susceptible than others, but no one can be excluded from the possible fear experience. Although some adaptation may be expected with repeat sonic booms, startle is a primitive response and whenever an adequate startle stimulus occurs, a startle response ordinarily follows.

The procedure used by the U.S. Environmental Protection Agency and the Department of Housing and Urban Development[37] to assess the impact of sonic boom exposures on people relates the long-term average C-weighted day-night average sound level produced by booms to the number of people that would be highly annoyed by the booms. This procedure was developed by the National Research Council of the National Academy of Sciences through its Committee on Hearing, Bioacoustics, and Biomechanics.[38,43] The C-weighted sound exposure level was chosen in lieu of the normal A-weighted level because it provides a more reasonable measure of the low frequency sound pressures associated with high-energy impulses such as those generated by sonic booms.[42] The procedure is based upon results from several laboratory studies and social surveys. One social survey was conducted in Oklahoma City where the residents were exposed to eight sonic booms each day for six months. During the course of this test, they were asked, on three separate occasions to assess their reactions to the sonic booms. Another social survey was conducted near an Army base where civilian residents were exposed daily to the noise from large artillery practice firings. Laboratory tests were designed to explore peoples' ability to judge the relative annoyance of sonic booms and subsonic jet aircraft flyovers.

Air Force studies of the Oceana MOA on F-15 aircraft indicated that, except for entry and exist of the MOA, air-to-air combat maneuvers were concentrated in an area roughly of an elliptical shape. The studies also indicated that all supersonic activities were further contained in a smaller ellipse, with dimensions of approximately 12 miles wide by 18 miles long, enclosing an area of approximately 170 square miles. Since the F-15 and F-16 use similar training scenarios, this same data will be used to estimate the impact of F-16 operations. Because of the geographical conditions beneath the Gandy airspace and because of the location of the existing supersonic flight airspace, the Gandy airspace is capable of facilitating three training areas, each with its own ellipse where supersonic activity will take place. The two main criteria for locating these elliptical areas as shown in Figure 8.0 are the geography of the underlying land and the horizontal spacing allowed between adversary aircraft. The areas are generally located over low-lying lands or valleys so that the aircraft can operate at their optimum elevation region (about 20,000 feet MSL) without worrying about mountain peaks or high ground reducing the safety buffer of airspace beneath them. The elliptical training areas should also be located far enough from airspace boundaries and other training areas so that adversary aircraft can begin their maneuvers at a distance of at least 40 miles apart. This horizontal spacing allows for effective training in the use of the aircraft's radar. Also shown in Figure 8.0 are the approximate locations of the elliptical training areas within existing supersonic flight airspace. As can be seen, should the proposed action be approved, the north ellipse in Figure 8.0 will extend into the existing supersonic flight airspace and one of the elliptical training areas over the existing airspace will extend into the proposed airspace. This type of arrangement should provide for the optimum use of the existing supersonic airspace.

Under worst case conditions the north, middle and south elliptical areas shown in Figure 8.0 would be used to accommodate 1,050 sorties per month that would involve supersonic flight. Because they are closer to Hill AFB, the north and middle ellipses would be more heavily used than the south ellipse. It is estimated that the north and middle ellipses would carry about 400 monthly supersonic sorties each and the south ellipse would carry the remaining 250. In Appendix B, the C-weighted day-night average sound level was calculated for the land areas beneath each of the three ellipses; the north and middle ellipses would have sound levels of 59.8 decibels and the south ellipse would have a level of 57.8 decibels. These figures were based on the average supersonic speeds and altitudes anticipated for the proposed actions: Mach 1.1 and 15,000 feet AGL (20,000 feet MSL) respectively. Utilizing an A-weighted day-night average sound level method, HUD has established that a location must have a sound level of less than 65 decibels to be considered acceptable for residential purposes. Studies have shown that for comparable values of C-weighted and A-weighted noise levels, people generally find the impulse noise described by the C-weighted method to be more annoying. These same studies have shown that in the decibel range being considered in this impact statement, a penalty of about 4.5 decibels should be added to the C-weighted sound levels in order to compare them with the annoyance associated with A-weighted sound levels. Even with these penalties added, the sound levels expected from the scenario described in this paragraph are generally considered acceptable for residential purposes.

Under these same worst case loading conditions (1,050 supersonic sorties per month in the Gandy airspace), a similar analysis could be performed assuming the worst case operating conditions. For this purpose the booms are all produced at 5,000 feet AGL (lowest allowed elevation) by aircraft traveling at Mach 1.3 (highest anticipated speed). If the same number of booms reach the ground as was assumed in the previous situation, the C-weighted day-night average sound level for land areas beneath the north and middle ellipses would have a level of about 67.4 decibels and the south ellipse would have a level of about 65.4 decibels. With the 4.5 decibel penality applied to these C-weighted levels, they would be 5 to 7 decibels higher than what would normally be considered acceptable for residential purposes. But, this scenario is unrealistically exaggerated.

The number of carpet booms likely to be heard at any point beneath an elliptical operating area can be estimated by the method described in Appendix C. These estimates are summarized below.

| Number of Booms Heard Per Day | Probability of Hearing Given Number or More Booms Per Day: Northern or Central Ellipses | Southern Ellipse |
|---|---|---|
| 1 | 0.86 | 0.71 |
| 2 | 0.56 | 0.33 |
| 3 | 0.27 | 0.10 |
| 4 | 0.10 | 0.02 |
| 5 | 0.03 | 0.01 |
| 6 | 0.01 | 0.01 |
| 7 | 0.01 | 0.01 |

As an example interpretation of these numbers, an individual living under the northern ellipse can except to hear two or more booms on slightly more than one-half of the days (from the table, 0.56), and on less than one day in one hundred would he hear seven or more booms. These probabilities drop off rapidly at distances more than 0.8 times the cut-off distance from the operating ellipse, reaching essentially zero at the cut-off distance. This outer limit where essentially no booms are expected is the same as the widest ellipse in Figure 9. A more detailed summary of expected sonic boom probabilities is found in Appendix C.

The situations described in the preceding paragraphs are worst case loading conditions. Under normal conditions there would only be about 719 air-to-air training sorties within the proposed airspace in one month and the flights would probably be divided up roughly between the north and middle ellipses with few going to the southern area. In this instance, the existing supersonic flight airspace would handle the remaining air-to-air sorties (450 per month). They would be accomplished in the two elliptical areas shown within the existing supersonic flight airspace area of Figure 8.0. With these conditions, C-weighted day-night average sound level contours could also be calculated for these two ellipses and they would be very similar to those shown on the south ellipse in Figure 8.0.

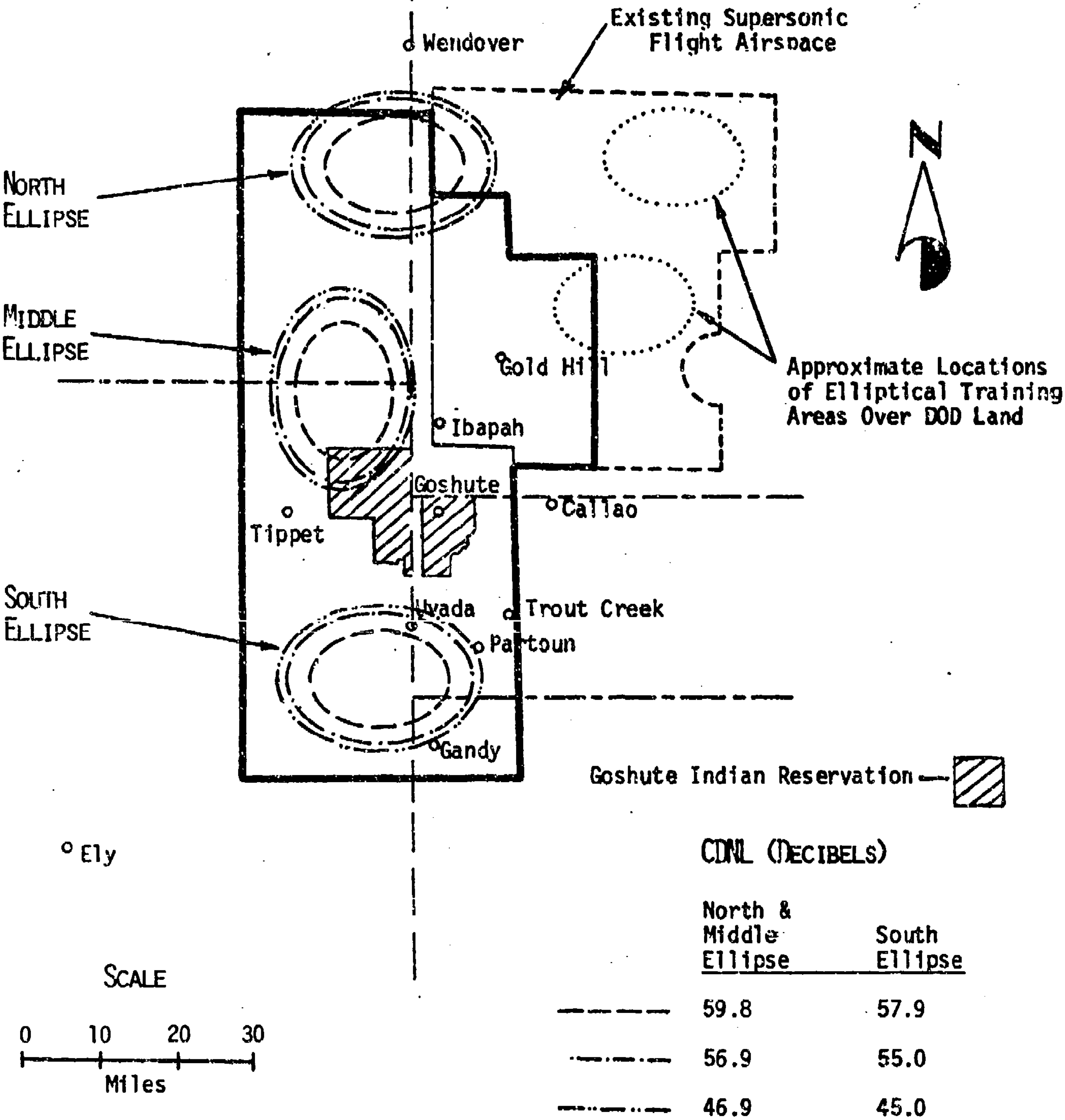



Figure 8.0

C-Weighted Day-Night Average Sound Levels (CDNL) of Supersonic Flight Ellipses

The C-weighted day-night average sound levels described in the preceding paragraphs are the result of sonic booms only; they do not include noise produced by subsonic aircraft operations. These subsonic operations, including both the air-to-air sorties and various other activities, were addressed in section 3.1.2.1. The exaggerated examples given in that section produced DNL levels of less than 48. The DNL and the C-weighted day-night average sound levels are very similar methods of describing noise; the DNL is based on an A-weighted measurement rather than a C-weighted. (The C-weighted measurement better quantifies impulsive sounds and their related structural vibration annoyances.) For estimation purposes the two average sound levels can be added together to get an idea of the noise impact of all aircraft operations within the proposed airspace. However, since decibels and the day-night average sound levels are logarithmic units, they cannot be added by arithmetic means, but must be added on an "energy basis". (As an example, if two levels are the same or 1dB different, the sum is simply the higher value plus 3dB. On the other end of the scale, if the two levels differ by 10dB or more, the sum is simply the higher of the two values.) Therefore, adding the exaggerated subsonic operation noise level to either of the C-weighted levels on the inner most ellipses in Figure 8.0, one obtains 59.8 or 57.8 decibels, the same levels already addressed.

Some experiments have shown a tendancy for sonic boom exposure to degrade the performance of certain visual, steering and tracking tasks, while others have shown no effect on performance.[20] Nowakiwsky (1974) subjected automobile drivers to sonic booms of 3 psf with no apparent affect on their ability to handle the vehicles. Sonic booms have also been reported to interrupt work, rest, recreation, school and other day-to-day activities. The actual acoustic masking effect of the boom is negligible because its duration is only a fraction of a second. However, the actual interruption will often last longer than the boom whether or not startle occurs; conversation and comments about the boom may continue after the fact, thought processes may be interrupted without immediate recovery, and group activities may require a short time to resume their previous business. It may take several minutes before the interrupted activity is fully resumed and order is restored in the case of groups of individuals. The response is largely dependent upon the individual subjects and the sonic boom overpressure.

Inhabitants of sparsely populated and quiet remote areas might reasonably be expected to be less tolerant of sonic booms. The responses undoubtedly will depend on individual natures. Callao is about 4 1/2 miles from the edge of the area. With normal operations occuring in the elliptical areas identified in Figure 8.0, this community will not be impacted. The western half of the Goshute Indian Reservation will be impacted by operations in the middle elliptical area and the locations identified as Uvada, Partoun and Gandy may be impacted from operations in the south ellipse area. However, of the three, this southern ellipse will be the least used. The community of Gold Hill may be impacted by operations occuring in the elliptical training area over existing supersonic flight airspace but only in unusual circumstances. From a standpoint of residents beneath the proposed supersonic flight airspace, operations in the middle ellipse would appear to represent the largest impact. The area of Ibapah could be impacted by overpressures from this ellipse under unusual atmospheric conditions. But, as stated previously, even beneath the interior ellipses, noise levels are considered acceptable for residential living. These areas are already subjected to periodic low level overflights at subsonic speeds. The fact that the residents of the area below the proposed airspace have already been exposed to noise from military aircraft may make them more tolerant to sonic booms or it may make them more sensitive, again depending on the individual.

4.1.2.2.2 Sonic Boom Effects on Animals:

Although domestic livestock have been observed during exposure to sonic booms, their reactions have not been conclusive and in most cases, indicated only recognition of a sound stimulus. One study indicated that sooty tern reproduction rates were severely reduced when the eggs were exposed to intense sonic booms with overpressures of 100 psf or more.[34] Generally, though, the magnitude of animal responses to sonic boom overpressure normally experienced has been slight.

Avain species will occasionally run, fly or crow. A series of tests conducted at the Agricultural Research Center, Beltsville, Maryland, also concluded that the behavior reactions of large animals to the sonic booms were minimal.[32] It was, however, noted that the reactions by animals were more pronounced to low flying subsonic aircraft than to booms. The reactions were of similar magnitude and nature to those resulting from flying paper, the presence of strange persons, or moving objects, which may indicate that stress may be pronounced when an object is seen. Observations reported by U.S. Fish and Wildlife Service (USFWS) personnel regarding responses of big horn sheep on the Luke Air Force Range, Arizona, to sonic booms indicate minimal impacts or disturbance to the sheep. These observations are listed in Appendix B.

Wild animals known to live in the region include small mammals, reptiles, antelope, mule deer, bobcats, mountain lions and other carnivore ranging from coyotes to ermine. Also, there have been documented sightings of numerous raptors and other avian species, including observations of high densities of golden eagles year-around with bald eagles using the area for winter habitat. Other wildlife in the area is characteristic of the western desert and mountain area. The only potential impact of the proposed action that might affect these species is the sonic booms resulting from the proposed training. Generally, the most delicate and sensitive behavior of animals is that associated with biological reproduction. Although sonic booms may, under extreme and unusual circumstances, affect this behavior, neither reproduction behavior modification nor adverse animal responses have been related to the type and magnitude of sonic booms that would be experienced beneath the proposed supersonic flight airspace.

A study[40] conducted in 1980 and 1981 under cooperative agreement between the USFWS and the Air Force, involved data gathering at 40 breeding sites of 8 species of raptorial birds in an effort to record responses to low level jets and sonic booms. Falcon and eagle species were subjected to a total of 1000 jet passes and over 100 real or simulated booms. During the 1980 portion of the study, boom responses were recorded at 15 eyries for 9 species (including 3 peregrine falcon eyries) and low level jet responses were recorded at 19 eyries (including 5 peregrine eyries) for 7 species. The objective in each experiment was to simulate a worst case situation (i.e., booms louder than normal or repeated passes with aircraft lower and closer than would be expected in routine low level maneuvers). The rationale being that if severe behavioral responses could not be generated in the worst case experiments, then one could logically conclude that responses to less intense stimuli would be less severe. The second year of the study concentrated on the peregrin falcon and its closest Arizona kin, the prairie falcon. Four pairs of prairie falcons were subjected to extreme test situations (i.e., the daily maximum for jet passes was 42 at one eyrie, and 23 booms at another) during the courtship - incubation phases of the nesting cycle when they were most likely to abandon. All phases of the breeding cycle were also tested in the peregrine. Finally, all sites tested in 1980 were revisited to determine reoccupancy rates. The conclusion of the study with regard to sonic booms are: (1) small nestlings do not respond noticeably, (2) large nestlings are alerted or alarmed - less often young will cower, (3) occasionally adults respond minimally if at all to loud booms, and (4) adult behavior indicative of site abandonment was not observed. The report further summarized by stating,

> "...while the birds observed for this study were often noticeably alarmed by the subject stimuli, the negative responses were brief and never productivity limiting. In general, the birds were incredibly tolerant of stimulus loads which would likely be unacceptable to humans."

Under the heaviest loading conditions expected, the land area beneath the elliptical airspaces identified earlier may experience as many as 14 sonic booms on a weekday. Any single location beneath the elliptical airspace will be subjected to only a portion of this number. Considering the relatively high altitude of the sonic boom activity and low numbers of sonic booms expected to be perceived by a single ground location within the area, the anticipated noise impact on endangered species and wildlife appears to be slight.

Cottereau of the National Veterinary School of Lyon, Lyon, France, reports in all the studies concerning sonic booms, whether real or simulated booms, the authors came to the same general conclusions: Sonic booms and subsonic flight noise has very little effect on the animals behavior. He goes further to say about sonic booms, "Chronic direct effects on wild animals have not been investigated, but no significant effects of [illegible] kind are presently foreseen."[15]

An FAA study[19] completed in 1973 arrived at the following conclusions:

1. Animal damage claims are only a very small fraction of the total damage claims that have been submitted to the Air Force.

2. The behavioral reactions of farm animals to sonic booms are, for the most part, minimal.

3. All experimental evidence to date indicates that the exposure of mink to sonic booms does not affect reproduction.

4. All experimental evidence to date indicates that the exposure of chicken eggs to sonic booms does not affect their hatchability.

5. Sonic booms do not appear to pose a threat to fish or fish eggs.

6. Knowledge concerning the effects of sonic booms on wildlife is limited, but it appears that sonic booms do not pose a significant threat.

While available data indicates wildlife and animals demonstrate limited response and no nestling death or eyrie abandonment, questions on long term protracted exposure and sublevel responses remain to be studied.

4.1.2.2.3 Sonic Boom Effects on Structures:

Three large scale tests account for the bulk of recorded data available in describing structural response to sonic boom overpressure. The most intensive test was conducted at White Sands, New Mexico, where 21 structures of various design and construction were instrumented and then exposed to more than 1,500 sonic booms with overpressures as high as 20 psf.[27] No damage was detected for overpressures up to 5 psf, nor was there evidence of any cumulative damage effects after a series of 806 successive flights at about 5 psf. The only evidence of damage at the conclusion of the tests, other than glass breakage, was three bricks that had loosened beneath a window ledge. Additional details on the White Sands study along with details on the other two large scale tests are provided in Appendix B.

The results of the three large scale sonic boom structural tests and several other tests were analyzed by NASA.[8] In their conclusion they make the following statement:

> The extensive series of overflight tests have provided valuable data on the order of magnitude of responses to be expected. These tests show that building structures in good repair should not be damaged at boom overpressures less than about 11 $lb/ft.^2$ However, it is recognized that considerable loading variability occurs, owing to atmospheric effects, and that the residual strength of structures varies according to usage and natural causes. Thus, there is a small probability that some damage will be produced by the intensities expected to be produced by supersonic aircraft.

By far, the largest percentage of sonic boom damage claims stems from broken or cracked glass damage. All of the tests conducted in the United States have confirmed that glass damage is the most prevalent damage caused by sonic booms.[16] As addressed in Appendix B, predicting whether or not glass will break due to a certain sonic boom overpressure depends upon various factors, i.e., the surface condition of the glass, the overpressure geometry and duration, the atmospheric moisture content and the composition of the glass itself. By using a data base of unpublished static test results provided by Libbey-Owens-Ford Company, a statistical analysis was performed to determine the probability of glass breakage for various overpressures.

If all flight paths are considered equally likely, that is, the aircraft could approach from any direction, then the probability of breakage for good glass at various nominal overpressures is shown below.

| Overpressures | Probability of Breakage |
|---|---|
| 1 psf | .000001* |
| 2 psf | .000023 |

* 1 pane in 1,000,000 panes

If the aircraft were to approach from head-on perpendicular to the plane of the window, the probability would increase somewhat, as shown below:

| Overpressures | Probability of Breakage |
|---|---|
| 1 psf | .000023 |
| 2 psf | .000075 |
| 4 psf | .001200 |
| 20 psf | .105000 |
| 40 psf | .323000 |

Note that for the overpressures previously discussed, around 4 psf, the probability of breakage is about one-tenth of one percent. Therefore, a few windows can be expected to be broken or cracked as a result of the sonic booms created in the proposed airspace. The Air Force has established procedures to recover the costs of damage resulting from sonic booms. Refer to section 4.6.3 for an explanation of the Air Force claims process.

4.1.2.2.4 Sonic Boom Effects on Terrain and Seismic Activity:

Several studies have been performed to study the magnitude of seismic effects resulting from sonic booms.[27] One study by Goforth and McDonald concluded that the static deformation that occurs at the surface is unlikely to build up sufficiently to constitute a menace to structures. As a part of the analysis, the peak particle velocity was determined for various geological formations. The damage potential of the peak particle velocities produced by the sonic booms is well below damage thresholds accepted by the United States Bureau of Mines and other agencies. Although identified as a concern by the State of Utah (see section 4.1.3), it is highly unlikely that the impact of sonic booms on geologic formations would be sufficient to generate landfalls or landslides.

There has been some concern that supersonic flights over mountainous areas could cause avalanches under certain conditions. In 1967, the National Park Service attributed damage to two National Park areas caused by falling earth and rock immediately after a sonic boom.[21] The only test in the United States to study the possibility of avalanches was conducted in the Star Mountain area near Leadville, Colorado.[27] Eighteen supersonic runs were studied with overpressures ranging from 1.5 to 5.2 psf. No avalanche was observed as a direct result of a sonic boom. Forest Service personnel rated the avalanche hazard as low during the test period and considered the test as inconclusive; therefore, the potential for sonic booms triggering avalanches remains largely unknown.

4.1.2.2.5 Sonic Boom Calculations:

A simplified method for the calculation of sonic boom charactertistics for a wide variety of supersonic aircraft configurations and spacecraft operating at altitudes up to 76 km (47.2 miles) has been developed. Sonic boom overpressures and signature duration may be predicted for the entire affected ground area for vehicles in level flight or in moderate climbing or descending flight paths. The outlined procedure relies to a great extent on the use of charts to provide generation and propagation factors for use in relatively simple expressions for signature calculation. Computational requirements can be met by hand-held scientific calculators, or even by slide rules.[6] The method is explained in detail in Appendix B. It uses basic aircraft operating conditions - Mach Number, altitude, weight, and flight path angle. The estimate provided by the method tends to be conservative; that is, the overpressure derived is the maximum possible. Other factors such as non-standard temperature and winds are not accounted for in this conservative analysis for the principle of simplicity. These factors tend to distort the sonic boom shock waves and most often decreases maximum overpressures.

The following chart shows the maximum overpressure to be expected directly under the flight track of F-16 operations in the proposed supersonic flight airspace at representative airspeeds and five altitudes. As distance from the flight track increases, the overpressure decreases as discussed earlier.

MAXIMUM OVERPRESSURE EXPECTED AT A GROUND LEVEL
ALTITUDE OF 5000 FEET MSL

| AIRCRAFT AIRSPEED M | ALTITUDE (MSL) OF AIRCRAFT | | | | |
|---|---|---|---|---|---|
| | 10,000 | 15,000 | 20,000 | 25,000 | 30,000 |
| 1.1 | 6.36 psf | 3.52 psf | 2.40 psf | 1.81 psf | 1.45 psf |
| 1.3 | 7.48 psf | 4.14 psf | 2.85 psf | 2.14 psf | 1.67 psf |

All these overpressures are well inside the limits of those overpressures expected to cause any structural damage other than occasional breakage of glass. Also, Air Force testing with fighter aircraft having capabilities similar to the F-16 have shown an average supersonic speed of Mach 1.106 during the short bursts of speed with only 0.3 of the booms created reaching the ground.

4.1.2.2.6 Sonic Booms Effects on Areas Beyond the Airspace Boundaries:

Sonic booms may be expected to travel beyond the area boundaries. The distance a sonic boom will travel depends on the aircraft altitude, airspeed, and atmospheric conditions such as prevailing winds. Using the decay rate equation, there would still be calculable overpressure at any lateral distance from the boom source. However, in reality these shock waves tend to refract back into the atmosphere. Since these laterally traveling shock waves travel further than those directly beneath the plane, they travel further through the atmosphere before reaching the ground and are refracted more. The lateral cutoff distance is that point where the shock waves start grazing the ground; at further lateral distances, the waves refract back into the atmosphere never reaching the ground. Atmospheric conditions such as prevailing winds may shift the lateral extent of the sonic boom to greater distances than the theoretical cutoff distance. The lateral shift will depend on aircraft altitude and wind speed, but will not normally shift the impacted area more than a couple of miles outside the calculated cutoff distance.

Under average operating conditions, the shock waves will travel only as far as the outer ellipses shown in Figure 8.0 (approximately 4.3 miles out from the innermost ellipse). At the maximum airspeed and minimum altitude allowed (M = 1.3 and 5,000 AGL), the maximum lateral cutoff distance of the sonic boom will only be about 1.4 miles from the aircraft flight track. At the same maximum airspeed but at 30,000 feet MSL, the maximum cutoff distance increases to 11 miles with overpressures substantially less than when the boom is created at 5,000 feet AGL. Under this set of conditions, the ground beneath the inner ellipses would experience overpressures of about 1.67 psf; and the overpressure on the ground at the 11 mile distance would die down to 0.30 psf. The above, 11 mile distance, represents the widest spread of sonic waves that is expected from the proposed action. With the booms being created in the elliptical airspace discussed earlier, the 11 mile cutoff distance would create on outer ellipse as shown in Figure 9.0.

When looking at Figure 9.0, it should be noted that all of the airspace contiguous to the eastern side of the proposed supersonic flight airspace is already within the restricted airspace of the UTTR. As such, the land areas below, like those below the proposed airspace, are already subjected to noise from military aircraft flying at subsonic speeds at elevations as low as 100 feet AGL. In fact, the community of Gold Hill is now close enough to existing "Southern Supersonic Flight Airspace" shown in Figure 2.0 that it is probably exposed to occasional sonic boom overpressures created in that airspace. By the same token the land beneath the northeastern corner of the Gandy Range Extension is most likely already exposed to occasional sonic boom overpressures because the existing supersonic flight airspace is adjacent to the Gandy airspace in this area. The most populous area that could be impacted by this worst case spread of shock waves is the Town of Wendover. Taking into consideration that this condition will rarely, if ever, occur and that Wendover is only on the fringe of the impacted area, there should be no adverse impacts on this community.

#### 4.1.3 Impact on Fish and Wildlife:

Several agencies and organizations, including the States of Utah and Nevada, have expressed concern over the proposed action's impact on fish and wildlife. Since these impacts are limited to those resulting from the sonic booms, they were addressed in section 4.1.2.2.2 of this document. As a review and specifically addressing the identified threatened or endangered

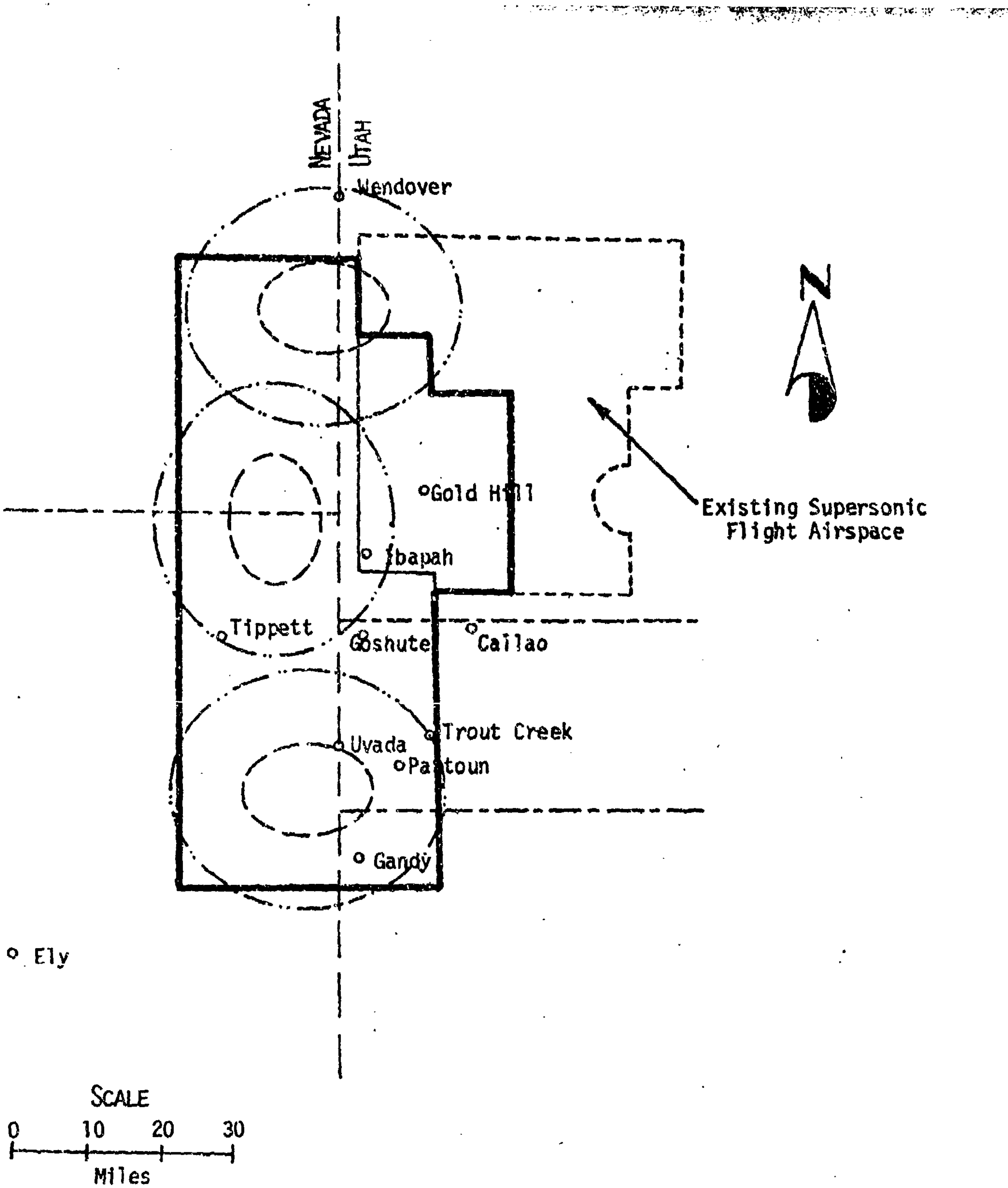



FIGURE 9.0
POTENTIAL AREA OF SONIC BOOM IMPACT
WITH WIDEST LATERAL SPREAD (11 MILES)

species in the area, it is anticipated that the proposed action will have no adverse impact on the bald eagle or peregrine falcon over those which may already exist due to the present low level operations by military aircraft. There are no documented sightings of the peregrine falcon in the area of concern, but the bald eagle is known to frequent some of the area. The impact on the spotted bat is unknown as, according to BLM, the extent of its distribution is also unknown. As indicated in section 4.1.2.2.2, sonic booms do not appear to pose a threat to fish or fish eggs and since the nearest identified population of the steptoe dace is northwest of the project site, no impact on this species is anticipated. Refer to section 3.1.4.2 for additional discussion on the population and extent of threatened and endangered species.

Another animal species of possible concern is the rare Snake Valley (Utah) cutthroat trout for which the Deep Creek Mountains is one of the few remaining areas of existence. The State of Utah has expressed the concern that the number of sonic booms impacting this habitat may result in landfalls and landslides which could block creeks, prohibiting fish movement and reproduction. As previously described in section 4.1.2.2.4 it is unlikely sonic booms would impact geological formations. Also the supersonic flight ellipses in Figure 8.0 do not extend into the Deep Creek Mountains. Therefore, normal supersonic operations should have no impact on this habitat.

### 4.1.4 Impact on Archeological or Historical Sites:

No specific archeological sites have been identified in the land area beneath the proposed supersonic flight airspace. However, there are several historical sites and monuments in the area that are associated with the old pony express and stage trail that skirted around the south end of the Great Salt Lake Desert. (Much of this desert is now DoD-owned land within the UTTR.) The trail cuts further south at Callao, going through Trout Creek and around the south end of the Deep Creek Mountains. The trail then turns north, preceeding to Tippett and through Antelope Valley. Once past the Antelope Range, the trail veers west and out of the area of concern. As a result of some preliminary scoping, the Utah and Nevada State Historical Preservation Officers have provided written determinations that the proposed action will have no impact on archeological or historical sites. However, the officers of both States will be sent copies of this document and again will be given the opportunity to identify any concerns they may have.

### 4.1.5 Impact on Air Traffic:

Private aircraft are not prohibited from use of the Gandy Range Extension portion of the proposed supersonic flight airspace. This airspace is under control of the FAA at Salt Lake Air Route Traffic Control Center (ARTCC), Salt Lake City, Utah. When the area is scheduled for military activities, the control is turned over to the 299th Communications Squadron of the Utah Air National Guard. As compared to current subsonic flight operations, supersonic flight training will not result in special procedures or operating limitations being placed on private aircraft. A majority of the general aviation traffic in this area can be expected to operate below 10,000 feet AGL and most supersonic training can be expected to take place above this elevation. The Gandy Range Extension MOA is depicted on the applicable sectional aeronautical chart to warn general aviation pilots of the specific utilization of the area by military aircraft. Based on this analysis, the proposed action should have minimal effect beyond current levels on general aviation in the area.

The Aircraft Owners and Pilots Association have expressed their concern that the see-and-avoid concept of collision prevention cannot be depended upon for aircraft operating at supersonic speeds. Their concern is that a high collision potential would exist between the USAF aircraft flying at supersonic speeds and non-participating Visual Flight Rules (VFR) civilian aircraft operating below positive control airspace within the Gandy MOA. However, existing military operations in the Gandy airspace already involve speeds approaching the speed of sound and a see-and-avoid concept should not be depended upon even in these instances. The best approach to avoid conflicts is for private pilots requiring access to the airspace to file pre-flight plans and pay attention to the Notices to Airman put out by the FAA. Even though the floor of the proposed supersonic airspace is 5,000 feet AGL, military aircraft operating at supersonic speeds may not always be under positive radar coverage with the 299th Communications Squadron.

### 4.1.6 Accidents:

When compared individually with subsonic air-to-air sorties, allowing the pilots to accomplish short bursts of supersonic speeds should not increase the potential for an aircraft accident (crash or jettison of external stores) and any ensuing effect on human life, property or animal life. However, if approved for supersonic flight, more air-to-air sorties will be scheduled for the airspace under consideration and the increased number of sorties would increase the chance of such an accident in that area. As of 31 December 1982, the F-16 at Hill AFB had accumulated 76,617 hours of flying time since it was introduced into the Air Force inventory at Hill in January 1979. During those hours there were sixteen major mishaps or accidents involving F-16's at Hill (fourteen within the 388 TFW and two within the international training unit, no longer located at Hill AFB). None of these accidents resulted in a loss of civilian life or property, but one did involve the loss of a military life. Although the above figures indicate a low probability of an aircraft accident affecting the area, resident fear and anxiety toward aircraft accidents may result from or be intensified by sonic boom activity.

## 4.2 Environmental Impacts of Alternatives:

### 4.2.1 No Action:

As would be expected with this alternative, all the environmental impacts associated with sonic booms as described in section 4.1, would not occur. Aircraft operations involving supersonic flight would be restricted to airspace already approved for these operations which is located over land controlled by the DoD. The proposed airspace would still be heavily used for aircraft training operations but not at supersonic speeds. The environmental impact of this alternative would amount to a "status quo", but the 388 TFW's training program would be significantly degraded. A majority of their air-to-air combat training flights would not be accomplished in airspace where the aircraft's full capability could be exploited. A true simulation of wartime situations could not be achieved on these flights and the pilot's wartime survivability could be impaired.

### 4.2.2 Alternative Airspace Within the UTTR:

The alternate training areas within the UTTR that were addressed in section 2.2.2.2 would experience similar environmental impacts to those expected beneath the proposed airspace and addressed in section 4.1. At any of these alternate airspaces, the air combat maneuvers would be accomplished at similar altitudes and the sonic booms generated would cause essentially the same overpressures at ground level. Available evidence indicates that domestic and wild animals are not significantly impacted by these overpressures and the analysis provided in section 4.1.2.2.1 indicates that the areas subjected to sonic booms are still suitable for residential living. The primary difference in environmental impact would appear to be the number of people present beneath the airspace that may be annoyed by the booms. Locating the operations in the Lucin MOAs (section 2.2.2.2.1) would impact more people than the proposed action while locating them in R-6402, R-6405, and the Sevier MOAs (sections 2.2.2.2.3 and 2.2.2.2.4) would impact similar numbers of people. The residential population beneath the Lucin MOAs is approximately 400 and the portions of R-6402, R-6405 and the Sevier MOAs in Juab and Millard Counties (Utah), the least populous portions of these areas, have a population of about 330. These later alternate sites are individually small in useable size and unless combined may not be capable of meeting the total training requirements. Also, use of these sites would not be able to take advantage of other existing UTTR training facilities such as inflight refueling and the HUS Arena. There is no clear cut environmental advantage (less populous areas) to the alternate sites within the UTTR and in most cases, they involve operational disadvantages.

### 4.2.3 Vertical Dimension Changes:

Any significant increase in the elevation of the proposed supersonic flight airspace would force pilots to deploy their aircraft at elevations where the maximum performance of the craft is decreased. Although this would decrease the noise impact at ground level, it would be a direct contradiction to the primary purpose of the proposed action which is to provide airspace where realistic combat training can be accomplished. Minor increases in the floor elevation (a few thousand feet) could possibly be made without affecting the normal aircraft maneuvering altitudes, but then the estimated noise impacts would remain the same. Only the maximum anticipated sonic boom overpressure levels would be decreased and it is estimated that sonic booms will seldom if ever, be generated at these lowest altitudes.

## 4.3 Relationship of Proposed Action to Land Use Plans, Policies and Controls:

A Notice of Intent describing the proposed action, identifying the Air Force's intention to prepare a Draft Environmental Impact Statement (DEIS), and soliciting comments was published in the Federal Register and mailed to the State and Federal agencies listed under section VII of this document.

The same information was also made available through a public news release. Prior to the notice of intent, additional scoping was accomplished at the local level. At that time, representatives of Hill AFB attended a session of the State of Utah's Environmental Coordinating Committee and a session of the Utah Aeronautical Committee to present the proposal and also met with representatives of the Nevada State Clearinghouse. This section will address the land use concerns voiced in the comments received from the various agencies and discussed at the meetings attended by Air Force representatives.

4.3.1 Access to Affected Area:

4.3.1.1 Land Access:

The Gandy Range Extension portion of the proposed supersonic flight airspace is now designated as a MOA and ATCAAA while the remainder is designated as restricted airspace. These designations have nothing to do with the movement or restriction of ground vehicles below. Likewise, the designation of the airspace above 5000 feet AGL as an airspace for supersonic flight has no impact on the movement of ground vehicles or ground access.

4.3.1.2 Access to Non-Military Aircraft:

Access to the airspace making up the Gandy Range Extension is of concern to private pilots traversing the area and to State and Federal wildlife agencies who travel through the area while performing aerial censuses of wildlife. Since the airspace is designated as a MOA and an ATCAAA, the Gandy Range appears on aviation maps to inform pilots that the airspace is a joint usage area (may be under military or FAA control). The area is designated as such on aviation maps with the objective that the potential for conflict between military and civilian aircraft be minimized. When at 15,000 feet AGL or above, all military flights in the area will be under radar surveillance by and in contact with the 299th Communications Squadron, the Utah Air National Guard unit with air traffic control responsibilities for the Range Complex. As described in section 2.1.2, radar coverage between 5,000 and 15,000 feet AGL is available in the northeast and central portions of the proposed airspace, but is limited in the southern portion. Any time the Range Complex is scheduled for military use or is "hot", air traffic control responsibilities will switch from FAA to the 299th or "Clover". During these "hot" periods Clover monitors all flights within the restricted airspace and the surrounding MOAs and ATCAAAs. The Air Force is now installing remote transmitters in the area of the Range to better insure radar coverage at all elevations. When the military schedules a MOA, such as the Gandy MOA, the FAA puts out a Notice to Airman (NOTAM) that the MOA has been activated. Any commercial or private pilots flying in the area under Instrument Flight Rules (IFR) would be notified of the activation as would any pilot filing a pre-flight plan. Because it is a MOA and ATCAAA, all military aircraft flying in the Gandy Airspace are required to operate under Visual Flight Rules (VFR) because of the possible presence of civilian aircraft. Likewise, civilian aircraft are required to operate under VFR because of the military aircraft. Although increased usage of the Gandy airspace by military aircraft (as will probably occur if approved for supersonic speeds) may make the area less attractive to civilian pilots it will not negate the joint usage policy now existing. The portion of the proposed supersonic flight airspace outside the Gandy Range Extension is within airspace restricted for military operations.

4.3.2 Recreation Plans:

4.3.2.1 Wilderness Areas:

The Wilderness Act of 1964 (PL 88-577) established a National Wilderness Preservation System consisting of wilderness areas to be designated on federal lands. Wilderness as described in the Act, is to be ". . . an area . . . untrammeled by man . . . with the imprint of man's work substantially unnoticable . . . (and that) has outstanding opportunities for solitude . . ." The Act further provides that "there should be no . . . permanent road, . . . no use of motor vehicles, motorized equipment, or motor boats, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any such area."

A portion of the Deep Creek Mountain range was identified by the Bureau of Land Management (BLM) as an inventory unit possibly having these characteristics as defined by the Wilderness Act of 1964. As such, field inventories of the area were conducted to determine the presence of absence of these qualities. As a result of this inventory, early in 1980 BLM identified a portion of the original Deep Creek Mountain inventory unit as a Wilderness Study Area (refer to Figure 10.0).

Since a portion of the Deep Creek Mountains has been identified as a Wilderness Study Area (WSA), a study will be conducted as part of a comprehensive land-use planning effort by BLM. During this study phase, the public will have several opportunities to comment upon other resource values within the WSA. These comments will be considered in making land-use decisions prior to subsequent recommendations to the President and Congress on the area's suitability or nonsuitability as Wilderness. Because the area has been identified as a WSA, it does not mean that it will be recommended as suitable for final designation as such by Congress. However, the BLM is required, under Congressional guidelines, to manage the WSA during the study phase to preserve wilderness value until a final determination on wilderness suitability or unsuitability is made. During this time, continuation of existing mining and grazing uses will be allowed, but actions (regulatory or otherwise) will be taken to prevent unnecessary or undue degradation of the lands and their resources.

It is not anticipated that the proposed supersonic activity would involve any irreversible damage to the unique qualities of the Deep Creek Mountains. There would be no landings of aircraft in the area, no dropping of live or inert ordance, no ground vehicles or equipment which might tend to conflict with a wilderness area. Also, when comparing Figure 10.0 to Figure 8.0, it can be seen that the elliptical training areas where sonic booms are expected to be generated are not located over the Deep Creek Mountains WSA. The altitude of these mountains make the airspace above unattractive for air combat maneuver training.

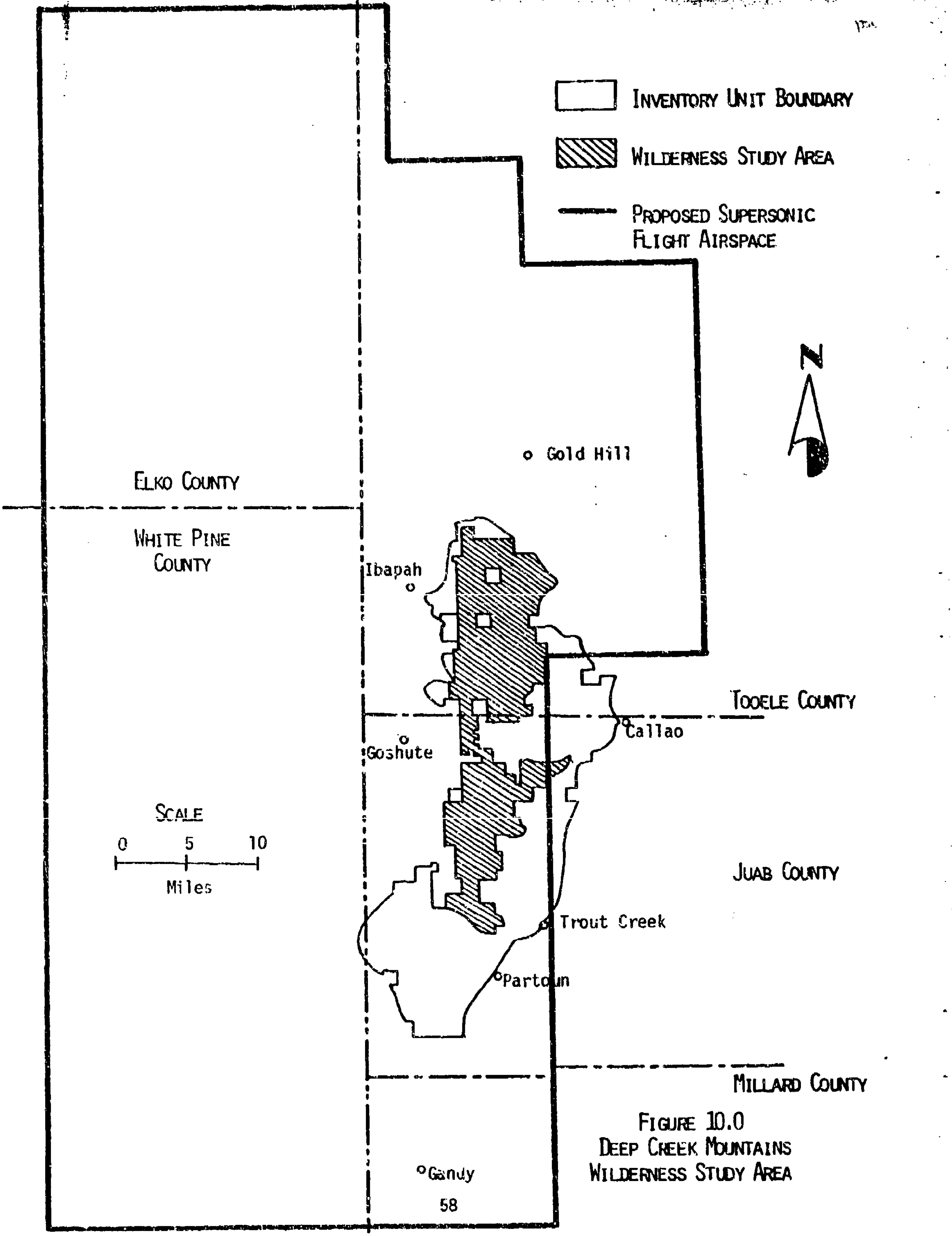



FIGURE 10.0
DEEP CREEK MOUNTAINS
WILDERNESS STUDY AREA

The Mt. Moriah unit of the Humboldt National Forest, less then 10 miles south of the Gandy Range Extension, has also been identified by the U.S. Forest Service for further wilderness study. The closest actual air-to-air combat maneuvers will be concentrated in an elliptical area 14 miles from Mt. Moriah. With the aircraft speeds and altitude proposed, shock waves will be refracted back into the atmosphere before traveling the 14 miles to Mt. Moriah.

4.3.2.2 National Park Proposal:

The State of Nevada has informed the Air Force that the area of the Snake Mountain Range, adjacent to the south end of the Gandy Range Extension, is being considered for the site of a proposed Great Basin National Park. The north tip of the Snake Range is shown in Figure 7.0 and does reach the southern boundary of the Gandy Range Extension. Under normal operations, the closest air-to-air training will be accomplished some seven miles north of this boundary with sonic booms created at about 20,000 feet MSL and at a speed of Mach 1.1. Under these conditions sonic boom overpressures will be refracted back into the atmosphere almost three miles short of this boundary. At higher speeds and higher altitudes this boom overpressure will impact more ground area, but will also weaken as it travels. Both the Rocky Mountain and Western Regions of the National Park Services will be provided the opportunity to comment on the proposed action.

4.3.2.3 General Recreation:

Recreational activities now taking place in the land area beneath the proposed supersonic flight airspace are of the outdoor, individual, or small group, wilderness experience nature. These activities include hunting, hiking, horse riding, camping, nature study, etc.. These are activities where the values of unspoiled nature are deliberately sought. Because of the remoteness of the area, the total number of people participating in these activities is expected to be small. Noise created by sonic booms would probably be annoying to some of the recreationists. The booms would be of very short duration and would tend to be concentrated in three elliptical areas located over valley floors as discussed in section 4.1.2.2.1. Recreational activities associated with the mountainous areas beneath the airspace would probably be impacted less than those associated with valley floors. The sonic booms will not involve any irreversible damage to the recreational capacity of the area. This annoyance is unavoidable. To the fullest extent possible, based on mission requirement, sensitive periods such as nightime and generally weekends, would be avoided, thus further mitigating possible annoyances.

4.3.3 Wildlife Mangement Plans and Policies:

Wildlife agencies have expressed concern over the possible conflict between the supersonic flight proposal and plans to reintroduce wildlife into the area. BLM and the Utah Division of Wildlife Resources are considering reestablishing bighorn sheep and the peregrine falcon in the Deep Creek Mountains. BLM may also introduce about 20 antelope near the Deep Creek Mountains, and intends to develop Salt Marsh Lake, east of the town Gandy, as a waterfowl habitat. Although flying operations, particularly with jet aircraft, always have the potential for bird strikes, these operations already exist and have provided no indication of significant bird strike problems in the area. Even considering Salt Marsh Lake, the overall land area has limited attractions for large numbers of feeding or nesting birds. Studies referenced previously indicate that sonic booms themselves should have no adverse impact on birds or other wildlife that may be reintroduced into the area beneath the proposed supersonic flight airspace. The impact of sonic booms on wildlife was addressed in section 4.1.2 of this document.

4.3.4 <u>Future Development:</u>

The State of Utah has expressed their concern that the proposed action would devalue those state lands acquired from Congress for the development or benefit of state institutions. They contend that any infringement on the potential for development by any agency would be in direct contrast with the 1894 mandate of Congress that set the lands aside. The impact of the proposed action on long-term development is discussed in the next section.

4.4 <u>Relationship Between Local Short-Term Uses of the Environment and Maintenance and Enhancement of Long-Term Productivity:</u>

Some of the State and Federal agencies contacted have voiced concern over the proposal based upon the potential for adverse impact the noise might have on wildlife, land values and recreational opportunities. Visitors traveling through the area are often attracted there because of its quiet, peaceful and tranquil rural atmosphere. There is concern that very concentrated sonic boom activity could adversely impact the future development of wildlife programs, recreational opportunities, and land values in the area, and result in these interests not being fully developed. In 1980, a contractor working for the Air Force finalized a study[39] on the economic impact of sonic booms on four existing supersonic flight MOAs. The four MOAs, Sells in Arizona, White Sands in New Mexico, Desert in Nevada, and Gladden in Arizona, had experienced supersonic activity since 1968, 1969, 1974, and 1977 respectively. The evidence obtained by this study allowed the contractor to make the following conclusions with respect to the impact of Air Force sonic boom activity:

(1) There was no influence exerted on population changes.

(2) There was no significant impact on employment and labor force growth in the study areas.

(3) There had been no loss of personal income, or slow down of growth which would have resulted in negative net improvements.

(4) There was no impact on the ability of retail trade to expand.

(5) There was no influential role played in assessed valuation changes within any of the seven counties of the four active supersonic flight MOAs.

(6) There was no impact on improvements in land values.

(7) The tourism industry in the study area had not been significantly impacted.

(8) There was no significant impact on the cattle ranching industry.

(9) There was no significant impact on the mining industry.

It is anticipated that the economic impact on the land area beneath the proposed supersonic flight airspace would be similar to that exhibited beneath the four study MOAs. The land areas beneath the four MOAs exhibit numerous similar characteristics to that beneath the airspace under consideration and in some instances have facets that would appear to be more sensitive to possible impacts (i.e., retirement home developments and tourism). Also, outside of the possible wildlife programs discussed eariler and the wilderness study proposed for a portion of the Deep Creek Mountains, there appears to be little indication that there are any significant plans for the future development of the land area beneath the proposed airspace.

The short-term impact of sonic booms on wildlife has been shown by several studies to be minimal. To date no studies have indicated any adverse long-term effects on wildlife.

### 4.5 Irreversible and Irretrievable Commitments of Resources:

There are no known irreversible or irretrievable commitments associated with the use of the proposed airspace for supersonic flight.

### 4.6 Action Taken or Proposed to Mitigate the the Adverse Environmental Impacts:

The following actions have been taken to minimize the impact of sonic boom activity on the environment beneath and near the proposed supersonic flight airspace.

#### 4.6.1 Area Altitude Design:

To minimize noise disturbances even in remote, sparsely populated areas, the minimum altitude for supersonic flight has been proposed at 5,000 feet above ground level. This minimum altitude was selected as a compromise to allow realistic training while minimizing the impact of sonic boom activity on the area environment.

#### 4.6.2 Minimum Weekend/Holiday Area Flying:

Use of the area for weekend/holiday supersonic flight training will be minimized. The policy for scheduling air combat training will be to first utilize that airspace already approved for supersonic flight which is located over DoD owned land. This airspace will generally be able to handle weekend/holiday supersonic flight training. This will minimize the noise impacts on the area during periods when the majority of people are participating in recreation, weekend retreat and tourism activities.

### 4.6.3 Damage Claims:

The Air Force will consider paying claims for alleged damage to private property resulting from sonic booms caused by Air Force operations. Generally, the amount paid for substantiated claims is based on the repair or depreciated replacement cost, whichever is less. The Air Force will also consider claims for personal injury resulting indirectly from sonic booms, although occurrences of this nature are extremely rare. The Claims Office at Hill AFB can provide required forms and information concerning claims policies and procedures. Claims and inquiries should be addressed to:

OO-ALC/JA
Hill AFB, UT 84056

It is the policy of the Air Force that whenever its non-combat activities, including sonic booms, cause damage, it will make payment of fair amounts for that damage. The claimant need not prove negligence on behalf of the Air Force or any of its members in order to receive payment. The claimant need only prove the cause and effect relationship between the sonic booms and the damage. Claimants can assist by making a record of the exact time when the damage occurred and/or a sonic boom was heard. Sonic boom damages can be repaired immediately at the claimant's expense. Actual repair costs/estimate should then be forwarded to the Hill Claims Office with required Air Force claims forms. Claims for damage may not be payable if (1) there was no Air Force activity being conducted at the time the damage occurred or (2) the damage resulted from other causes; for example, structural deficiencies.

### 4.6.4 Considerations that Offset the Adverse Environmental Effects:

The F-16 is a lightweight single engine, multirole tactical fighter configured for both air-to-air and air-to-ground operations. The aircraft's small size and low weight enable it to operate from any airfield with an improved runway now being operated by the United States Air Force. The F-16 weapons system is essential for national security. Peacetime training is designed to optimize wartime combat effectiveness and survivability. Due to the advanced performance characteristics of the F-16, supersonic flight is required if pilots are to effectively employ the aircraft in the role for which it was designed and procured. The availability of adequate supersonic flight airspace insures that realistic F-16 training is accomplished in a timely, operationally effective and economical manner. Realistic tactical flying training is the keystone of the readiness and combat capability of tactical aircrews. Peacetime training programs tailored directly to expected wartime threats are essential to the mission of the Air Force and thus the National Defense.

Supersonic flight training in the proposed supersonic flight airspace would directly enhance the combat capability of the 388 TFW by increasing the quantity and quality of realistic training airspace. Combat ready pilots would be able to fully explore the aircraft performance capabilities and develop, practice and refine sound combat tactics and habit patterns in the supersonic flight regime - the employment regime required for combat effectiveness and survivability. Increased supersonic flight training would be locally available so that costly and operationally unsuitable alternatives such as inflight refueling and satellite operating bases to allow use of distant supersonic flight training areas would not be required. Assuming that no action would be an unacceptable alternative due to its potential adverse impact on the combat capability of the 388 TFW, the use of the study airspace for supersonic flight training would have minimal impacts on the local environment although sonic boom noises could be annoying to some residents.

### 4.7 Details of Unresolved Issues:

Because of the area's rural population and remoteness, area residents are accustomed to a life style free from encroachment of modern civilization. At the time of this document's preparation, the Air Force had contacted only those State and Federal agencies identified under section VII of this document. Issues identified by these agencies have been addressed in the text of this document. There have not yet been any other public announcements or public meetings on the proposed action. Individuals living within the area could well express fear that sonic boom activity will damage human and animal populations, area structures and generally retard any future economic growth of the area. The Draft Environmental Impact Statement will be filed with the Environmental Protection Agency and made available for public review and comment. Comments received during the public review and comment period will be addressed in the Final Environmental Impact Statement as necessary.

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## VII. LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THE STATEMENT ARE SENT:

The following agencies and individuals were contacted regarding this proposal or have expressed a concern in the action. Pertinent comments received are addressed in the text and a copy of the DEIS will be sent to each of the listed addresses.

### State

#### Utah

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The DEIS is being provided to all parties contacted regarding the proposal or from whom correspondence has been received. Copies of the DEIS will also be provided to the following libraries to increase its public availability.

Utah State Library Commission
2150 South 300 West
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Tooele Public Library
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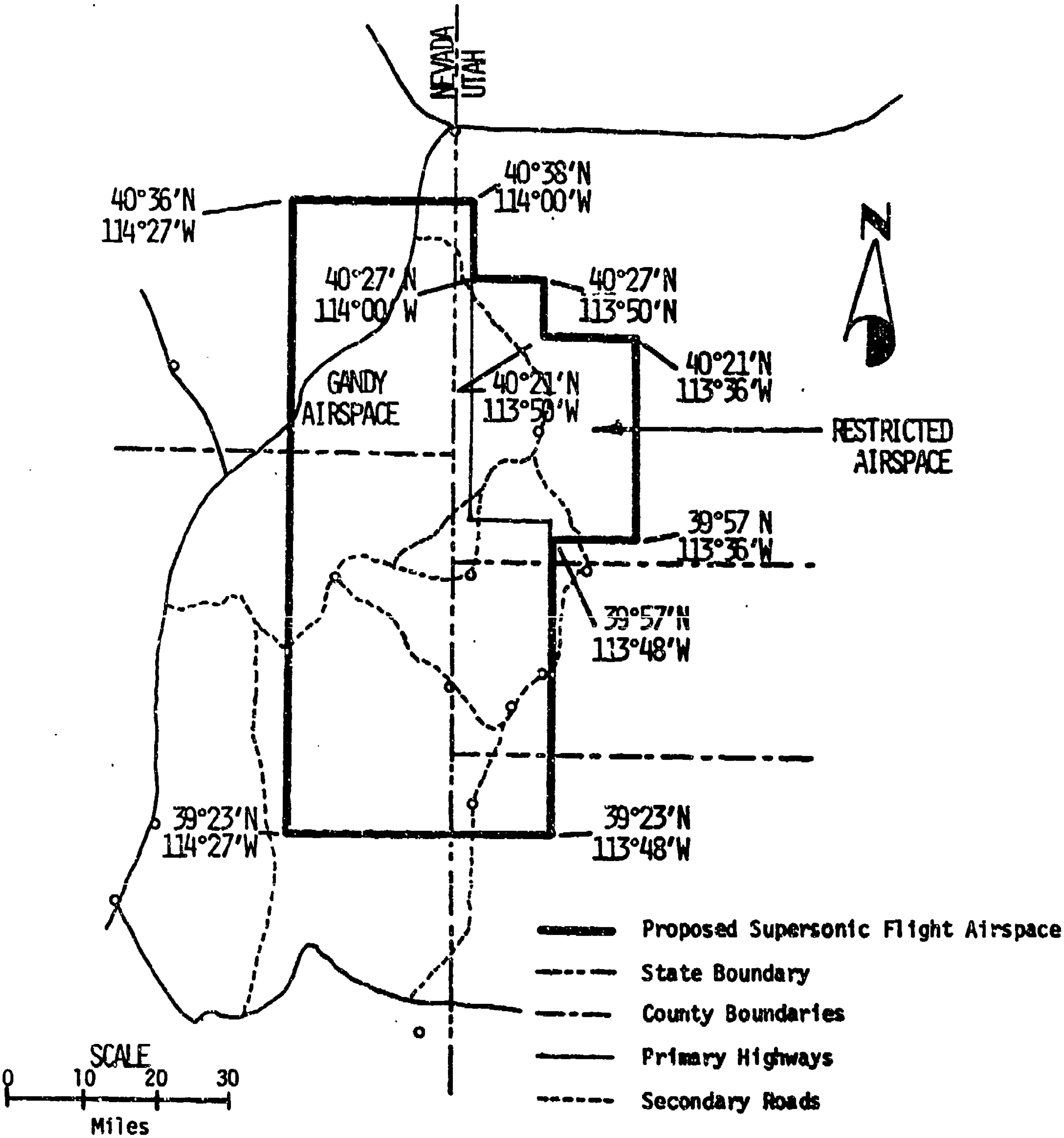
# APPENDIX A

## PROPOSED SUPERSONIC FLIGHT AIRSPACE

## GEOGRAPHIC COORDINATES/AREA MAP




GANDY AIRSPACE

MOA - 100' AGL to but not including FL 180

ATCAAA - FL180 to and including FL 580

RESTRICTED AIRSPACE - Ground level to and including FL 580

# APPENDIX B

## SONIC BOOM

## CHARACTERISTICS

## APPENDIX B

## SUPERSONIC AIRCRAFT AND SONIC BOOMS

### PREFACE:

Introduction of advanced aircraft such as the F-15 and F-16, designed to operate at supersonic speeds in combat, has created a need for conducting realistic training at these speeds. One result of supersonic flight is the creation of a wave of compressed air in front of the aircraft. This is heard and felt, as a sudden loud impulse noise and is called a "sonic boom." The purpose of this appendix is to discuss causes and types of sonic booms, and their potential environmental and physiological effects.

### SCOPE:

Sounds are atmospheric disturbances detected by the human ear through changes in air pressure on the ear drum. These pressure changes are extremely small and are propagated through the air at the speed of sound--about 760 miles per hour at standard sea level pressure and temperature of 59°F.

A sonic boom may be defined as an acoustic phenomenon we hear when an object exceeds the speed of sound. When the speed of an aircraft is faster than the speed of sound, the air in front of the aircraft is compressed, forming a shockwave. An individual actually hears the change in pressure when air molecules are first compressed and then returned to a more normal state. The pressure differential across the shock wave is relatively large (larger than that produced by speech pressure changes) and is very sudden. As a result the human ear perceives the rapid change in pressure as an impulsive type sound very much like the crack of a whip or a rifle shot.

With the spectacular rise in the maximum speed of military aircraft in the last three decades and the need to adequately train and maintain military pilot proficiency, sonic booms have become an increasing phenomenon in various parts of the United States. Because a sonic boom manifests itself as sound to the human ear, we tend to forget that it is actually a sudden change in pressure that may have an effect on people, structures, animals and wildlife. The most important effects are obviously those that man experiences; however, we must also be concerned with effects in other areas as well.

Since the late 1940s when aircraft first broke the so-called "sound barrier", studies and experiments have been conducted primarily to determine the effects of sonic booms on people. During the fifties and sixties as sonic booms became more prevalent in the United States, studies were expanded to include the effect on structures. Studies have also been made to determine the effects of sonic booms on domestic animals, livestock and, more recently, on wildlife. The discussion which follows will summarize the background and the latest available information for sonic booms.

## BACKGROUND OF SONIC BOOM THEORY:

The movement of bodies at speeds greater than the speed of sound has been studied for well over 200 years. Forces produced by gunnery projectiles were determined at speeds up to Mach 2 (twice the speed of sound) as long ago as 1742. Ernst Mach, a professor of physics in Vienna, published papers as early as 1887 encompassing both mathematical and experimental studies of supersonic flow. Studies by Prandtl (1907), Meyer (1908) and Ackeret (1925) were precursors to the virtual explosive rate of progress in the study of supersonic flow during the thirties, forties, and fifties. From 1959 to 1964, after aircraft routinely achieved supersonic flight, a great deal of experimental work was done in wind tunnels and in flight tests to investigate the validity of the basic theories previously developed.

Sonic booms may sound the same to the human ear; however, as early as 1947 Hayes[x] derived a mathematical model subsequently called the "Supersonic Area Rule" which demonstrated that each aircraft or supersonic projectile generated its own particular pressure source which was dependent on the area cross-sections cut out by the Mach wave. Figure 1 is a simplified drawing of the pressure wave generated by a body in supersonic flight. The pressure signature is referred to as an N-wave because of the characteristic shape of the signal as recorded on electronic monitoring devices. In 1952, Whitham[x] enlarged on the cross-section idea and developed a formulation which combined the individual pressure sources making it possible to calculate the pressure field of real aircraft configurations. These calculations only considered the volume effect of the supersonic bodies as contributing to the distant disturbance field. Subsequent work by Busemann in 1955, Walkden in 1958 and Morris in 1960 considered the lift distribution created by the fuselage and wings.[x] The end result of all these later investigations was to show that at low altitude, the lift effects were relatively unimportant but for large airplanes at high altitudes the lift effects became dominant.

Other factors such as atmospheric variations also have an effect on the magnitude of sonic boom overpressure.[y] Atmospheric pressure and temperature, like the speed of sound vary with altitude. In the early development of sonic boom calculations, no detailed analytical method would account for atmospheric variations. It was assumed that flight was in a homogeneous atmosphere. Today, however, there is extensive information available to help determine atmospheric effects on sonic booms.

In 1964, H.W. Carlson of NASA and the Boeing Company developed digital computer methods and programs to calculate a realistic source distribution that could be applied to computation of the distant pressure field. The distant pressure field or far field is the pressure normally heard by an individual as the sonic boom sound or noise. The far field pressure ($\Delta P$) can be calcualted using a simplified formula developed by Carlson and Maglieri of NASA.[w] The simplified method is explained in detail at the end of this discussion and some representative overpressures calculated.

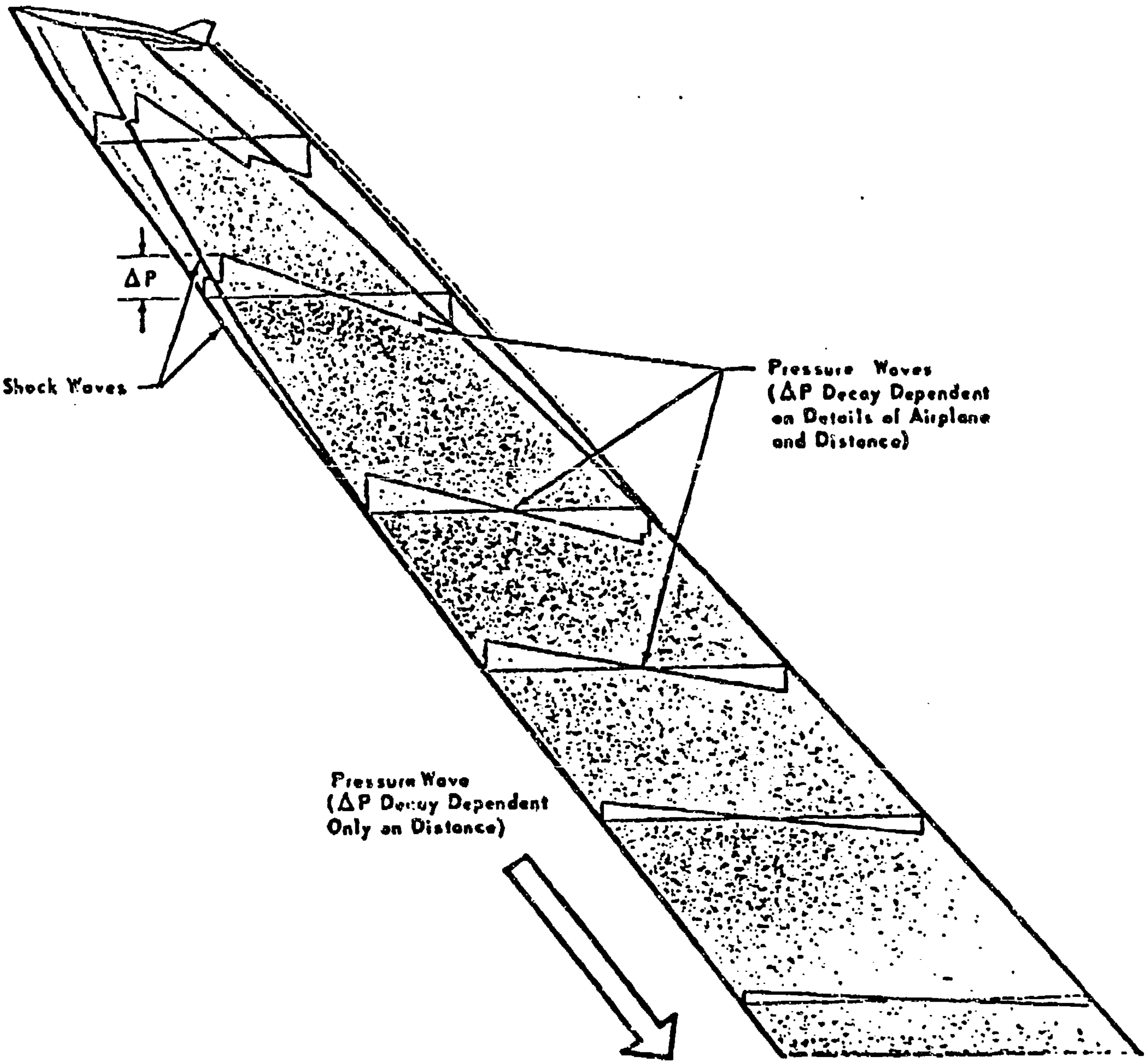



Figure 1. Simplified Sonic Boom Diagram Showing "N-Wave".

## SONIC BOOM CHARACTERISTICS:

### Straight and Level Flight:

A supersonic aircraft in straight and level flight produces a sonic boom pattern on the ground which can be likened to a moving carpet. The intensity of the sound and overpressure at ground level generated by the boom is largely dependent upon the altitude and airspeed of the aircraft. Peak overpressures occur directly under the centerline of the aircraft, diminishing at the edge of the carpet to approximately 0.5 to 1.0 pounds per square foot. Figure 2a is a depiction of a "carpet" type boom. Occasionally, multiple overpressures occur in the same area. These are produced by shock waves emitted from the front and rear of a single aircraft and recognized as two closely spaced booms of similar intensity.

Although a sonic boom is produced when an airplane is supersonic, not all booms will be heard on the ground. The atmospheric air temperature decreases with height above ground. This temperature gradient acts to bend the sound waves of a sonic boom upward. Depending upon the aircraft height and Mach number, the paths of many sonic booms are bent upward sufficiently that the boom never reaches ground level. The heights and Mach numbers produced during F-15 combat maneuvering are such that less than one boom out of every three produced is likely to be heard at ground level. This same phenomenon also acts to limit the width of those sonic booms that do reach ground level. The maximum lateral distance reached by the booms is normally designated as the lateral cutoff distance.

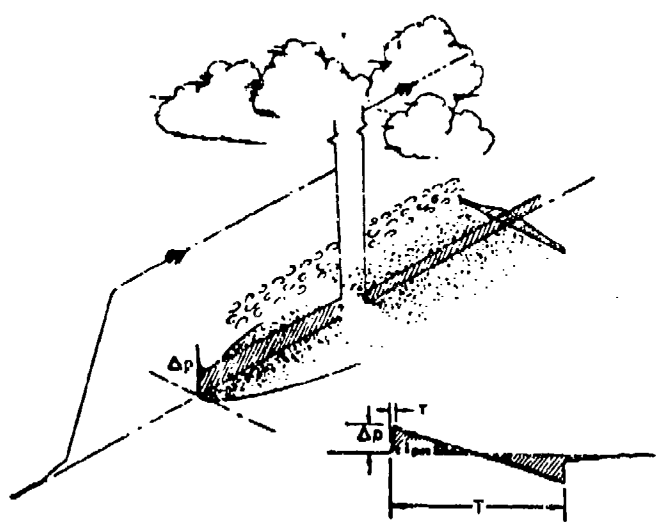



Figure 2a - Sonic boom ground-pressure patterns. - "Carpet Boom"

Maneuvering Flight:

The majority of supersonic flight for fighter type aircraft is directly associated with air combat maneuvering training. Airspace required for a normal engagement of two aircraft is usually represented as a vertical cylinder of airspace with a diameter of approximately 8-10 nautical miles. (This diameter represents the approximate maximum distance one can see another fighter aircraft with the naked eye. In practice, an elliptical rather than circular cross section is more representitive of the airspace required.) Supersonic flight is confined within this airspace. The maneuvering during an engagement is oriented toward the vertical within the airspace of the cylinder. Each engagement may last from two to four minutes and at its conclusion the aircraft reposition for the next engagement. This repositioning process may take from three to five minutes at subsonic speeds. Two to three individual engagements may take place during a single training period and involve either two or, at a maximum, four aircraft. Sonic booms generated by this training may differ considerably in area impacted and intensity from the "carpet" boom produced by a single aircraft in straight and level flight. Some of the booms may be intensified by interactions of the various pressure wave fronts generated. These are sometimes called "focus booms".

Focus Booms:

Supersonic activity that occurs during air combat maneuvering or acceleration may produce what is often referred to as an intensified or focused boom. These intensified booms can result from various airplane maneuvers which result in pressure buildups at ground level above the pressure created by the aircraft in steady rectilinear flight. In general, the total ground area receiving such sonic booms from air combat maneuvering is substantialy reduced from that impact by "carpet" booms. While the area of these "focus" booms is small (a few hundred feet wide and limited in length) when compared to the "carpet" boom, the intensity and overpressure may be higher than a "carpet" boom by a factor of two to five. Duration does not vary significantly. The "focus" boom will only affect a fixed area on the ground, i.e., the boom does not move along the surface with the aircraft as does a "carpet" boom. In each maneuver, pressure buildups occur in the localized regions suggested by the shaded areas shown in the sketches in Figure 2b. Illustrated are three types of maneuvers which could result in pressure buildups at ground level (a longitudinal acceleration, a 90° turn and a pushover maneuver). The effects can be minimized by reducing acceleration rates and turn rates. The turn focus does not always reach the ground if a large radius turn is used. The pushover focus does not always reach the ground if a small curvature of the flight path is used. Pull-up maneuvers and deceleration do not produce a focus boom.

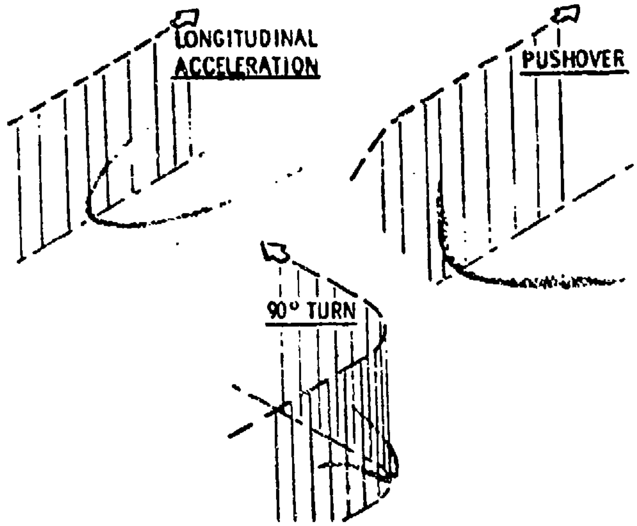



Figure 2b - Areas on the ground exposed to focused sonic booms resulting from three different airplane maneuvers.

Combined Maneuvering:

Air-to-air intercept training events, as a part of combat air maneuvering training, present the worst situation in regard to sonic booms and their possible effects on the ground environment. This training event initially employs the aircraft's radar system to acquire and engage a target aircraft and combines straight and level flight (sometimes at supersonic speeds) at medium and high altitude until visual engagement maneuvers are initiated. Traces of a number of flight paths of F-15 aircraft at the Ocean MOA show that, except for this entry and exit, maneuvers are concentrated in an area roughly of an elliptical shape.[GG] The origin of the ellipse is midway between the two navigational reference points where radar contact between the opposing aircraft began. These two points are generally about 40 miles apart and the major axis of the ellipse is along the line connecting them. For F-15 aircraft the elliptical maneuvering area is approximately 20 miles wide by 34 miles long. Within this area, supersonic flight is contained within a smaller ellipse, with the same origin and principal axes as the larger. Traces of representative flight tracks show that in the Oceana data, an aircraft can be at any location within the ellipse during a sortie. The radar portion of the intercept is complete upon simulated missile release. The engagement then often continues as a visual air combat maneuvering engagement with both aircraft still supersonic, but now within the elliptical airspace with maneuvering oriented to the vertical. Thus, the air intercept portion of combat air maneuvering training may result in a combination of the "carpet" sonic boom and additional "focus" booms in one event.

Upper Atmosphere Propagation (Secondary Boom Carpet):

Another factor that should be mentioned in sonic boom characteristics is the long range "over-the-top" sonic boom propagation in the upper atmosphere. In most instances of supersonic flight activity there are actually two patterns of exposure detected at ground level. These two patterns can be designated the primary and secondary boom carpets.[HH] The primary boom carpet is formed by the normally observed sonic boom overpressures resulting from shock wave propagation through the atmosphere below the aircraft. The center of this carpet is directly beneath the flight track and extends out laterally as far as the cutoff distance. The secondary boom carpet is generated from shock waves that are moving upwards until they reach that region of the atmosphere where temperature increases as altitude increases (the inverse condition to what normally occurs at lower elevations). In this area the shock waves are refracted back toward the ground. These upward moving shock waves can be generated in the atmosphere above the aircraft or they can be generated from the shock waves orginating below the aircraft after they have bounced off the ground (inside the primary boom carpet) or have been refracted upwards without touching the ground. The secondary carpet can be pictured as an oblong doughnut sitting around the primary carpet. Between the primary and secondary carpets there exists a region in which no sonic booms are observed.

In the region of the primary boom carpet, on or near the ground track, N-wave type signatures are typically observed with overpressures in the 1 to 5 psf range and durations of 100 to 300 milliseconds. At the fringes of the primary boom carpet, near the lateral cutoff, the signatures degenerate into weak sound waves, and they lose their N-wave characteristics. In the region of the secondary boom carpet, the disturbances tend to be very weak in intensity (0.001 to 0.01 psf) but persist over longer periods.[HH] It is the higher overpressure N-wave-type sonic booms that have caused community acceptance problems. On the other hand, the lateral cutoff booms and the secondary carpet booms tend to be more of a curiosity and are not apt to cause community response problems. The secondary carpet booms are generally not even audible, but can cause building vibrations which may be observed. Because there is generally no significant impact associated with the secondary boom carpet, it will not be discussed further.

HUMAN RESPONSE:

Of the many field studies conducted to better understand community response to sonic booms, the three most extensive were conducted over St Louis, Oklahoma City, and Edwards Air Force Base.

St Louis, Missouri[A] -- during the early 1960s, St Louis was exposed to sonic booms over a seven-month period. A total of 76 flights of supersonic aircraft were made (with several aircraft per flight), producing over-pressures up to 3 pounds per square foot (psf). After the flights, a random sampling of residents revealed the following:

- About 90% experienced some interference with speech, activities, etc.

- About 35% were annoyed.

- Less than 10% contemplated complaint action.

- A fraction of 1% actually filed a formal complaint.

- The number of formal complaints was proportional to the number of supersonic missions, i.e., as missions progressed, formal complaints increased.

- A large proportion of formal complaints mentioned building damage.

- No adverse physiological effects were noted.

Oklahoma City, Oklahoma[B] -- Slightly more than 1250 sonic booms were generated over Oklahoma City during the spring and summer of 1964. The average weekly intensity of over-pressure was increased from 1.13 psf to 1.60 psf over the period of the test. Over-pressures during the test ranged from 0 to 3.5 psf. Almost 3000 adults, representing a cross-section of local residents, were interviewed three times during the six-month test. Based on responses to various questions asked during the interviews, the group was divided into those considered "favorably disposed toward aviation" and those classified as "unfavorable" similar to those found in the St Louis test. There were exceptions, however, as indicated below:

- About 3% of the "favorable" group felt like complaining about the booms and less than 2% actually did, while 37% of the "hostile" group felt like complaining and 12% did.

- At end of the test, 73% of the total group felt they could learn to live with eight booms per day indefinitely.

- Reactions of urban and rural residents to sonic booms were essentially the same.

- Persons who filed formal complaints with the FAA were much more intensely annoyed and hostile toward the supersonic aircraft than were non-complainers. These individuals reported 3 to 4 times more sonic boom interference, four times more annoyance, 6 to 9 times more desire to complain and 3 times more damage by booms. They placed less importance on aviation in general, the necessity of supersonic travel or the necessity of local booms. Complainers were more often middle-aged females with older children and smaller families. They generally had more education and income and more often had ties with the aviation industry. About 40%, however, felt they could learn to live with eight sonic booms per day.

Edwards AFB, California[C] -- In 1967, residents from the base and two nearby communities occupied indoor and outdoor test sites and reported their physiological reactions to sonic boom over-pressures in the range of 1.5 to 3.0 psf. Test results were as follows:

- Those indoors reacted to an over-pressure of 1.69 psf as unacceptable in the following proportion: 50% of the residents from the two communities; 27% of the residents from the base.

- Those outdoors reacted to an over-pressure of 1.69 psf as unacceptable: 59% from the two communities; 33% from the base.

- Including all tests, outdoor listeners found booms slightly less acceptable than indoor listeners. Additionally, reaction of outdoor listeners was more consistent.

- Age and sex were not statistically significant parameters in the rating and sonic boom repetitions did not increase acceptability.

Physiological effects of sonic booms have been studied in several countries and over a variety of human conditions.

In Russia[D], tests were conducted to determine the effect on brain and heart potential, blood chemistry, arterial pressure, auditory acuity and visual response delay. Results showed that sonic boom intensities of up to 1.72 psf cause very slight shifts in these human functions. These shifts did not exceed the normal range of fluctuation and returned to normal in one to two minutes.

The University of Toronto Insitute for Aerospace Studies[E] exposed individuals to 25 sonic booms per minute for two minutes at over-pressures of 2, 4 and 8 psf. Results showed that booms of up to 8 psf had no detrimental effect on human hearing or heart rate, but that over-pressures of 4 psf would be considered unacceptable to most people. Impacts of over-pressures greater than 8 psf were not examined.

The committee on Hearing, Bioacoustics and Biomechanics of the National Academy of Science, National Research Council[F], published damage risk criteria recommending limits to peak impulsive noise levels as a function of impulse duration for a nominal exposure of 100 impulses per day. For impulse noises such as the sonic boom the limit is 140 db which equates to approximately 4.17 psf booms. This criteria is designed to protect individuals from experiencing a permanent threshold shift in hearing over a long term (20 years) period.

Tests have been conducted to determine the effect of sonic booms on sleep, task performance, loudness annoyance and startle acceptability and many other areas[V]. The Sonic Boom Literature Survey encapsulates 92 investigations in the human response to sonic booms. The following general conclusions can be drawn from these tests:

- The most frequently reported complaint in regard to sonic booms is house rattles and vibrations.

- Booms of similar intensity are slightly less acceptable to listeners outdoors.

- In all tests conducted thus far there has been no evidence of direct personal injury resulting from sonic booms.

- On the basis of experimental evidence to date, an acceptable sonic boom over-pressure compatible with undisturbed sleep cannot be given.

- Some experiments have shown a tendency for sonic boom exposure to degrade the performance of certain visual and motor tasks, while other tests have shown no effect on performance. The response is dependent upon the individual subject and the sonic boom over-pressure.

At the request of the U.S. Environmental Protection Agency, the Committee on Hearing, Bioacoustics and Biomechanics (CHABA) of the National Academy of Science has reviewed the available data on human response to sonic booms and has recommended a procedure for assessing the impact of sonic booms and other high-energy acoustical impulses on residential living.[11,33] This procedure relates percent of a population that would be expected to be highly annoyed by the sonic boom environment to the C-weighted day-night average sound level (abbreviated as CDNL) in decibels. This measure is the long term average of the C-weighted sound levels accumulated over a 24 hour period, with a 10 decibel penalty to events that occur after 10:00 p.m. and before 7:00 a.m. The C-weighting is a standardized frequency response found on sound level measuring equipment. The C-weighting puts more emphasis on the sounds of low frequencies than the A-weighting used for more common sounds such as traffic noise or subsonic airplane noise.

The CDNL for sonic boom exposures can be calculated from the expression:

$$L_{Cdn} = \overline{L_{CE}} + \log_{10} (N_d + 10\, N_n) - 49.4$$

Where $\overline{L_{CE}}$ is the logarithmic average of the C-weighted sound exposure level of individual booms, $N_d$ is the number that occur between 7:00 a.m. and 10:00 p.m., $N_n$ is the number that occur from 10:00 p.m. until 7:00 a.m., and 49.4 is ten times the logarithm of the number of seconds in a 24 hour day, relative to a one second reference period. An equation to calculate C-weighted sound exposure levels is given for the F-16 on Page B-26.

The relation between CDNL and the percent of a population that, on average, would be highly annoyed is:

| CDNL | Percent Highly Annoyed |
|---|---|
| 50 | 3 |
| 55 | 6 |
| 60 | 12 |
| 65 | 23 |
| 70 | 39 |

STRUCTURAL RESPONSE:

Following are general observations from 100 investigations of structural response to sonic booms.

- The largest percentage of sonic boom damage claims has been for glass damage. Plaster damage is second.

- The direction of boom propagation in relation to the orientation of a structure is very important.

- Sonic booms with over-pressure of 3 psf to 5 psf can cause minor damage to plaster on wood lath, old gypsum board and bathroom tile, new stucco, and suspended ceilings already damaged.

- A supersonic flight which produces 1 psf over-pressure can be expected to break 68 per million exposed glass panes. Breakage will occur almost entirely in already cracked windows. Breakage rate of new glass properly installed should be about 1 pane per million.

- Seismic effects resulting from sonic booms are well below structural damage thresholds.

Three large scale tests account for the bulk of recorded data available in describing structural response to sonic boom over-pressure. These include the Oklahoma City and Edwards AFB tests mentioned previously and a test conducted at White Sands in 1965.

Oklahoma City, Oklahoma[G] -- Eleven typical types of residential structures were instrumented and exposed to eight sonic booms per day at over-pressures of zero to 3.5 psf. The test program consisted of 26 weeks of eight daily controlled sonic booms having intensities in the range 0 - 3.5 psf (medium peak over-pressure of 1.2 psf) followed by thirteen weeks of observation and inspection of the structures to determine the normal rate of deterioration as compared to the rate of deterioration found during the 26 week sonic boom period. The major conclusions reached as a result of this investigation were as folows:

- There was no conclusive evidence of significant damage to the test houses. However, there was a significant increase in the occurrence of minor paint cracking over nail heads and in corners in two of the test houses during the sonic boom period, suggesting that sonic booms accelerated this minor deterioration.

- Measured deflection of window glass in the test houses was not sufficient to cause damage.

- Maximum free ground over-pressure alone is of little value in making structural response calculations since the shape and duration of the pressure wave acting on the structure, plus the natural frequency of the structural element must be taken into consideration.

- For a given aircraft producing N-waves of constant length, the impulse of the wave (positive area under the pressure-time plot) can be more closely correlated with some structural responses than can over-pressure. However, impulses from one aircraft should not be directly compared with impulses produced by a dissimilar aircraft for purposes of structural response.

Edwards AFB, California[H] -- Typical wood frame houses, as well as long span steel frame industrial buildings, were instrumented and subjected to over-pressures of two and three psf. Booms with durations of 0.1 second (fighter aircraft) and 0.2 second (bomber aircraft) were produced to determine wall displacement (flexing). The measured plate response of three gypsum board/wood stud/wood siding walls and one large plate glass window, and the measured racking response of two typical wood frame houses, one one-story and one two-story, were analyzed in detail and compared with the response predicted using boom signatures. The following were the most significant findings of this study:

- Sonic booms from large aircraft such as the XB-70 affect a greater range of structural elements (those elements with natural frequencies below 5 cps) than sonic booms from smaller aircraft such as the B-58 and F-104.

- Peak plate displacements of three typical walls in the two test houses were less than 0.034 inches for sonic boom over-pressure of approximately 2 psf. Racking displacements were extremely small at the roof lines of the two test houses (.005" and .0018") for sonic booms on the order of 2 psf.

- Structural response could be adequately predicted using peak over-pressures and Dynamic Amplification Factor (DAF) spectra calculated from free-field signatures.

- No sonic boom damage was observed in test structures prior to or after the test flights.

- Since the condition of the glass panes at Edwards AFB was determined prior to the test program, the number of damaged panes caused by booms from test missions should be an indicator of glass damage to be expected from supersonic flights generating peak over-pressures of 2-3 psf. The rate was one damaged pane per 7.9 million boom-pane exposures. This rate was 27 percent of the rate for buildings in communities adjacent to Edwards which were not condition surveyed prior to test missions.

- Fifty-eight percent of all incidents of damage for which complaints were received were listed as possibly caused by sonic booms generated by test program flights. Of these valid incidents, 80 percent were for glass, 5.5 percent for plaster or stucco, ad 14.5 percent for bric-a-brac or other fallen object damage.

White Sands, New Mexico[I] -- Twenty-one structures were instrumented and exposed to 1500 booms with over-pressures up to 20 psf. Insight was gained into large and small building reactions to sonic booms. No damage was detected for over-pressure up to 5 psf, nor was there any evidence of cumulative damage effects after a series of 860 successive flights producing 5 psf. One boom of about 40 psf was generated accidentally. The structural test area included 21 buildings varying in design, construction, and age. The following are the most significant conclusions reached as a result of this study:

- The direction of boom pressure propagation in relation to the orientation of structure or structural element is very important to its reaction. For example, booms traveling directly into a window cause the window to react more violently than do booms traveling away from the window.

- The peak pressure recorded on an exterior wall surface is influenced by the wall rigidity. The stiffer the wall, the higher the pressure.

- Reflecting surfaces such as billboards or houses placed beyond 15 feet from an external house wall do no significantly modify the peak boom pressure applied to the wall. Depending on orientation of the wall and the reflecting surface with respect to the aircraft flight direction, an increase in peak pressure can be expected when the reflecting surface is closer than 15 feet from the wall.

- Motion of the frame holding a window does not significantly influence the response of large windows framed by stud walls.

- The average transmissibility of large windows (8' x 10'), defined as the ratio of peak inside to peak outside pressure, can vary between 0.5 (boom wave directed into window) and 1.0 (boom wave directed away from window).

- The transmissibility of a room appears to be governed more by the size of the window walling the room than by room volume.

- Booms cause exterior walls to move more than interior walls in the minimum damage index level for walls in small houses, such as those used in the test. Bellows distortion may govern wall damage for larger houses, but the associated minimum damage index level for the larger houses could be larger than that observed in these tests.

- To study the cumulative effects of repeated sonic booms, 680 successive flights at a scheduled over-pressure of 5.0 psf were generated during one period of the study. No damage to previously undamaged material was identified during this period.

- Bricks on the sill below a picture window in one of the test houses were cracked by the accidental sonic boom. This was apparently caused by the window flexing outward after being pushed inward by the boom over-pressure (the glass was not damaged).

The results of the three large scale sonic boom structural tests and several other tests were analyzed by NASA.[AA] In their conclusion they make the following statement:

> The extensive series of overflight tests have provided valuable data on the order of magnitude of responses to be expected. The tests

show that building structures in good repair should not be damaged at boom over-pressures less than about 11 lb/$ft^2$. However, it is recognized that considerable loading variability occurs, owing to atmospheric effects, and that the residual strength of structures varies according to usage and natural causes. Thus, there is a small probability that some damage will be produced by the intensities expected to be produced by supersonic aircraft.

One additional investigation is worthy of mention. In 1977 an adobe house in southern Arizona was instrumented and evaluated while superosnic training was taking place overhead.[BB] The conclusion of the evaluation was that the adobe structure reacted similar to a conventional style structure. Based on this analysis, there should be no difference in the probability of damage to an adobe structure or a conventional structure.

## EFFECTS ON TERRAIN AND SEISMIC ACTIVITY

Several studies have been performed to study the magnitude of seismic effects resulting from sonic booms.[X] One study by Goforth and McDonald concluded that the static deformation that occurs at the surface is unlikely to build up sufficiently to constitute a menace to structures. As a part of the analysis, the peak particle velocity was determined for various geological formations. The damage potential of the peak particle velocities produced by the sonic booms is well below damage thresholds accepted by the United States Bureau of Mines and other agencies. The peak particle velocities recorded at a depth of 44 feet were attenuated by a factor of 75 relative to those recorded at the surface. The maximum ground particle velocity is of the order of 0.1 millimeters per second for each psf of sonic boom over-pressure.[X]

There has been some concern that supersonic flights over mountainous areas could cause avalanches under certain conditions.[CC] In 1967, damage in two National Parks was attributed to falling earth and rock. In both incidents, the falling earth and rock were preceeded by sonic booms. The only test in the United States to study possibility of avalanches was conducted in the Star Mountain area near Leadville, Colorado.[X] Eighteen supersonic runs were studied with over-pressures ranging from 1.5 to 5.2 psf. No avalanche was observed as a direct result of a sonic boom. Forest Service personnel rated the avalanche hazard as low during the test period and considered the test as inconclusive; therefore, the potential for sonic booms triggering avalanches remains largely unknown.

## STATISTICAL STUDIES OF DAMAGE

Data was gathered from the Oklahoma City and St Louis test as well as a test in Chicago to determine the number of complaints and damage claims submitted by the public.[X] Data also was used to verify damage claims and dollar value of claims paid. Most claims involved broken glass and cracked plaster in more poorly constructed and maintained homes. Injury claims to people or animals were very few and of an indirect type, such as injury resulting from falling objects, broken glass or self injury due to startle.

From 1956 to 1970, the amount of money claims for structural damage was $30.6 million while the amount paid was $1.7 million. For the years up to and including 1968, 65% of all paid claims were for glass and 18% were for plaster damage.

By far, the largest percentage of sonic boom damage claims stems from broken or cracked glass damage. All of the tests conducted in the United States have confirmed that glass damage is the most prevalent damage caused by sonic booms.[3] Because the microstructure of glass is amorphous rather than crystalline, the practical design strength of glass is a surface condition property rather than a constant material property. What this indicates is that the strength of the glass is dependent on the surface scratch condition. Glass that has been sandblasted, scratched, or nicked will not exhibit the same strength as a properly installed, relatively new pane of glass.

In addition to the variation due to surface scratch condition, there are also variations with loading geometry, loading rate, atmospheric moisture content, and composition. Glass also exhibits a property known as "static fatigue" in that it is weaker for loads of longer duration. Thus for sonic boom loading, which has a duration of the order of 0.1 sec, the strength of glass will be roughly twice that obtained in typical laboratory assessments. By using a data base of unpublished static test results provided by Libbey-Owens-Ford Company, a statistical analysis was performed to determine the probability of glass breakage for various over-pressures. If all flight paths are considered equally likely; that is, the aircraft could approach from any direction, then the probability of breakage for good glass at various nominal over-pressures is shown below.[3]

| Overpressures | Probability of Breakage |
|---|---|
| 1 psf | .000001* |
| 2 psf | .000023 |

*1 pane in 1,000,000 panes

If the aircraft were to approach from head-on or perpendicular to the plane of the window, the probability would increase somewhat, as shown below:

| Overpressures | Probability of Breakage |
|---|---|
| 1 psf | .000023 |
| 2 psf | .000075 |
| 4 psf | .001200 |
| 20 psf | .105000 |
| 40 psf | .323000 |

ANIMAL RESPONSE:

Controlled investigations of animal reponse to sonic booms began in 1965 with study of the effect of hatchability of chicken eggs. It was resumed in 1967 when the response of farm animals to sonic booms was studied as part of the Edwards Air Force Base sonic boom experiments. Subsequent studies were concerned with the response of cattle and horses to extremely intense booms (80 to 144 psf), with effects on fish and on reindeer, mink and fish eggs.

The following are general conclusions drawn from investigations of animal response to sonic booms:

- The animal damage claims are a small fraction of total sonic boom damage claims submitted to the Air Force.

- Reactions of farm animals to sonic booms are minimal.

- Evidence indicates that exposure of mink to sonic booms does not affect reproduction.

- Sonic booms do not affect the hatchability of chicken eggs nor do they affect fish or fish eggs.

- Although knowledge concerning the effects of sonic booms on wildlife is limited, all evidence to date indicates that animals, under most circumstances, are unaffected. Sonic booms may, under extreme and unusual circumstances (booms in excess of 100 psf) adversely affect wildlife, as in the case of the Sooty Tern incident (see next page).

Individual wild, domestic or pet animals exhibit different reactions to sonic booms according to the species involved, whether the animal is alone, and some cases whether there has been previous exposure. Common reactions are moving, raising the head, stampeding, jumping and running. Avian species may run, fly or crowd. Animal reactions vary from boom to boom and are similar to low-level subsonic flights, helicopters barking dogs, blowing paper and sudden noises. The reponses are either unrecognizable or consist of an apparent alerting accompanied by trotting off a short distance. Damage claims have been submitted by farmers and livestock breeders concerning loss resulting from sonic booms. Primary complaints have been that the productivity of animals was adversely affected and that panic and injury often resulted from the startle reaction. From Air Force claims records between 1961 and 1970, $900,000 in animal claims were made and $128,000 in damages awarded. The largest amounts were connected with mink production ($610,000 in claims and $100,000 in damages paid) with claims for chickens and horses following.[L]

Several experiments have been conducted to investigate the physiological animal response to sonic booms. Studies under various tests were: Effect on hatchability of chicken eggs; cattle and horse response; effects of intense booms (80 to 144 psf) on fish; reindeer; mink; and fish eggs. In other studies no significant responses or production changes were found for pheasants, chickens, turkeys, sheep, dairy and beef cattle or horses.[M] Bell reported that between 1961 and 1970, claims submitted to the Air Force for chickens, horses, and cattle totalled $144,000 but only $21,500 was actually awarded in damages.[L]

Mink Reactions:

Two extensive investigations of mink response to sonic booms, ranging in over-pressure from 0.5 psf to 2.0 psf in one test and 3.6 psf to 6.6 psf in the second test, found that no adverse effect on reproduction or behavior resulted from the booms.

Chickens:

Two tests were conducted to investigate sonic boom effects on hatchability of chicken eggs. One study carried out in Texas in 1965 exposed a total of 3,415 hatching eggs to 30 booms per day over a 21 day period. Over-pressures ranged from 0.75 psf to almost 6 psf. No deviations in the hatch rate were found in this test. A second test conducted in France in 1972 exposed hatching eggs to six booms per day. The hatched chicks from these eggs were all normal.

Fish:

Testing of fish eggs and guppy reaction to sonic booms was conducted in the early 1970s. Trout and salmon were reared from egg stage to maturity in the usual manner except for exposure to sonic booms in the range of 1 psf to 4 psf. No abnormal increase in mortality rate was noted. Guppies were exposed to shock waves of 550 psf (in the air). The fish detected the passage of the shock wave and reacted momentarily, however, no adverse effects were noted in observations during two months subsequent to the shock wave exposure.

Reindeer:

A study of reindeer reaction to sonic booms revealed that at low levels of over-pressure (0.3 psf to 0.5 psf) the animals react with temporary muscle contraction and minimal or undetectable interruption of activities. Higher levels of over-pressure (up to 10.5 psf) caused the reindeer to raise their heads, look around and sniff but never produced a reaction strong enough to bring resting animals to their feet. Panic movements were not observed, but neither was adaption to startle noted.

Sooty Terns:

One well documented incident reveals that supersonic over-pressure may have affected a wild bird reproduction rate. During 1969 in a Sooty Tern breeding colony of a Florida Key, the birth rate of young terns was 1.3% of the expected rate. Possible causes including weather, predation, food shortage, over-dense vegetation in the colony, pesticides, and disturbance by man were investigated and discounted. Three very intense sonic booms between May 4 and May 11 may have caused embryo damage due to egg abandonment or physical damage to uncovered eggs. (Overpressures of 100 psf or more have been generated by aircraft flying supersonically within 60 feet of the ground.) Birth rates in preceeding and succeeding years were normal.

Bighorn Sheep:

Correspondence from U.S. Fish and Wildlife Service personnel managing the Cabeza Prieta Wildlife Refuge, Arizona, listed observations of bighorn reactions to sonic booms.[EE] The observations were reported as follows:

9/13/78 Plomosa Mtns, 1 ewe, 1 yrlg, 3 class II rams, 2 cl. III rams. Activity - all animals bedded down (sonic boom) animals stayed in position, standing but frozen, then entire band ran about 20 yards upslope, huddled, alert, stayed in this position for about 15 minutes then moved uphill towards new shaded area.

1/3/79. Plomosa Mtns. 6 ewes, 2 yrlgs. Activity - feeding (sonic boom) no visible reaction.

May 1979. New Water Mtns, 2 ewes, 2 lambs. Activity - bedded down (sonic boom) sheep twisted their heads and stared in several directions, none of the animals rose.

3/21/79. Kofa Mtns. 3 rams. Activity - walking up hillside (sonic boom) sheep stopped, looked around and continued walking up hillside.

3/22/79. Kofa Mtns. 13 rams. Activity - part of band bedded down, part standing around (sonic boom) bedded sheep jumped to their feet, standing sheep bolted about five yards, in about 5 minutes sheep began to feed and bed down again.

## SONIC BOOM CALCULATIONS:

A simplified method for calculating the sonic boom characteristics for various aircraft shapes has been developed as discussed earlier. The sonic boom over-pressure and signature duration may be predicted for the entire affected ground area for aircraft in level flight or in moderate climbing or descending flight paths. The procedures for calculation of the predicted sonic boom by the simplified method involves three basic steps: determination of an aircraft shape factor, evaluation of atmosphere propagation factors, and calculation of signature shock strength and duration.

The effects of flight-path curvature and aircraft acceleration are not considered in using the simplified method. The method is further restricted to a standard atmosphere without wind. These limitations, however, do not appear to affect the general applicability of this method for normal variations from the standard atmosphere and for moderate flight-path curvature and aircraft acceleration. A variety of correlations of predicted and measured sonic boom data for aircraft and spacecraft has served to demonstrate the applicability of the simplified method.

The simplified method is illustrated in Figure 3 where:

$\Delta p$ = Maximum over-pressure expected

$K_L$ = Lift parameter

$P_v$ = Atmospheric pressure at aircraft altitude

$P_g$ = Atmospheric pressure at the ground

$K_s$ = Shape factor

$K_p$ = Pressure amplification factor

M = Mach No.

W = Weight

$l$ = Length of aircraft

h = Height of aircraft above ground

Several cases were chosen for study representing the range of altitudes in which training aircraft would be conducting air combat maneuvering. Since ACM type training is the major source of sonic booms, supersonic activity involving primarily the F-4, F-15, and F-16 was selected. For each aircraft, boom strengths were calculated for altitudes ranging from 15,000 to 30,000 feet mean sea level. The calculations were made for the aircraft in steady rectilinear flight (constant speed, straight and level flight). Table 1 illustrates the over-pressures of sonic booms for various altitudes. Table 2 shows the extent (width) of sonic booms at various airspeeds and altitudes and provides the intensity of the boom at cutoff.

Boom Duration:

The N-wave duration ($\Delta t$) can be estimated by the relationship:

$$\Delta t = \frac{2(\gamma+1)\ M\ r^{0.25}\ Z^{0.75}\ K}{\gamma\ \beta^{0.75}\ a_h}\ s$$

where:

$r$ = Slant Range (distance from observer to aircraft)

$a_h$ = Speed of Sound at Aircraft Flight Altitude

$\gamma$ = 1.4 (the ratio of specific heats)

$\beta = \quad M^2-1$

(Other variables are as described on previous page.)

Sonic Boom Cutoff:

The temperature gradient in a standard atmosphere refracts sonic booms upwards. Booms caused by aircraft at low Mach numbers, depending on aircraft height, h, above ground, will not propagate to the ground. The Mach number below which this occurs, and above which will result in booms reaching the ground, is called cutoff mach number, and is symbolized as $M_c$. The cutoff Mach number is approximately given by:

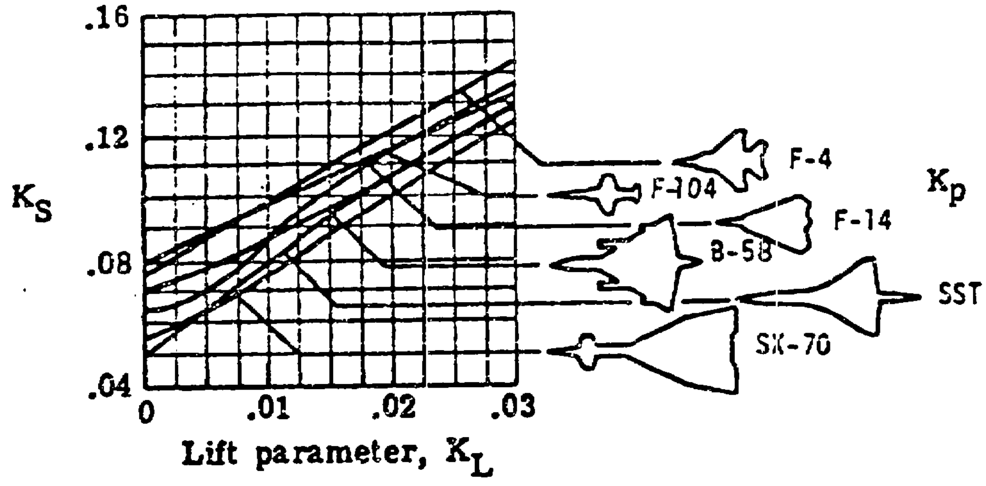
$$M_c \approx e^{4.033 \times 10^{-6} h} \qquad h \leq 35{,}300 \text{ feet}$$

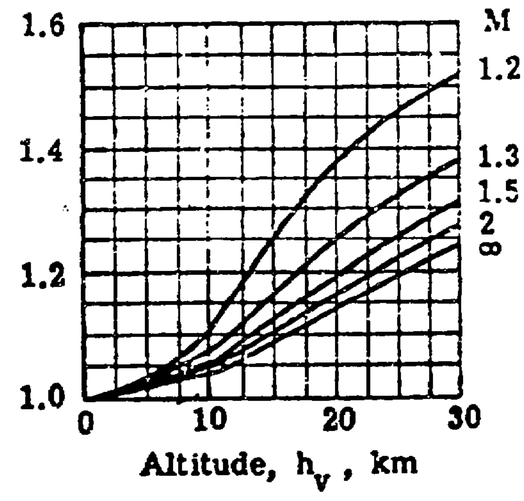
$$M_c = 1.153 \qquad 35{,}300 \leq h \leq 51{,}000 \text{ feet}$$

A similar process works to limit the distance a sonic boom will propagate to the side of a flight path, where again cutoff occurs. This distance, $d_{y,c}$, in feet, may be calculated from,[W]

$$d_{y,c} = h\ \frac{(1+M_c)}{M} \left(\frac{M^2-M_c^2}{M_c^{\,2}-1}\right)^{1/2}$$

Where h is height of the aircraft in feet, and M is the aircraft Mach number.




(1) Enter lift parameter $K_L$

$$K_L = \frac{\sqrt{M^2 - 1}\ W}{1.4 p_v M^2 l^2}$$

Select shape factor $K_S$

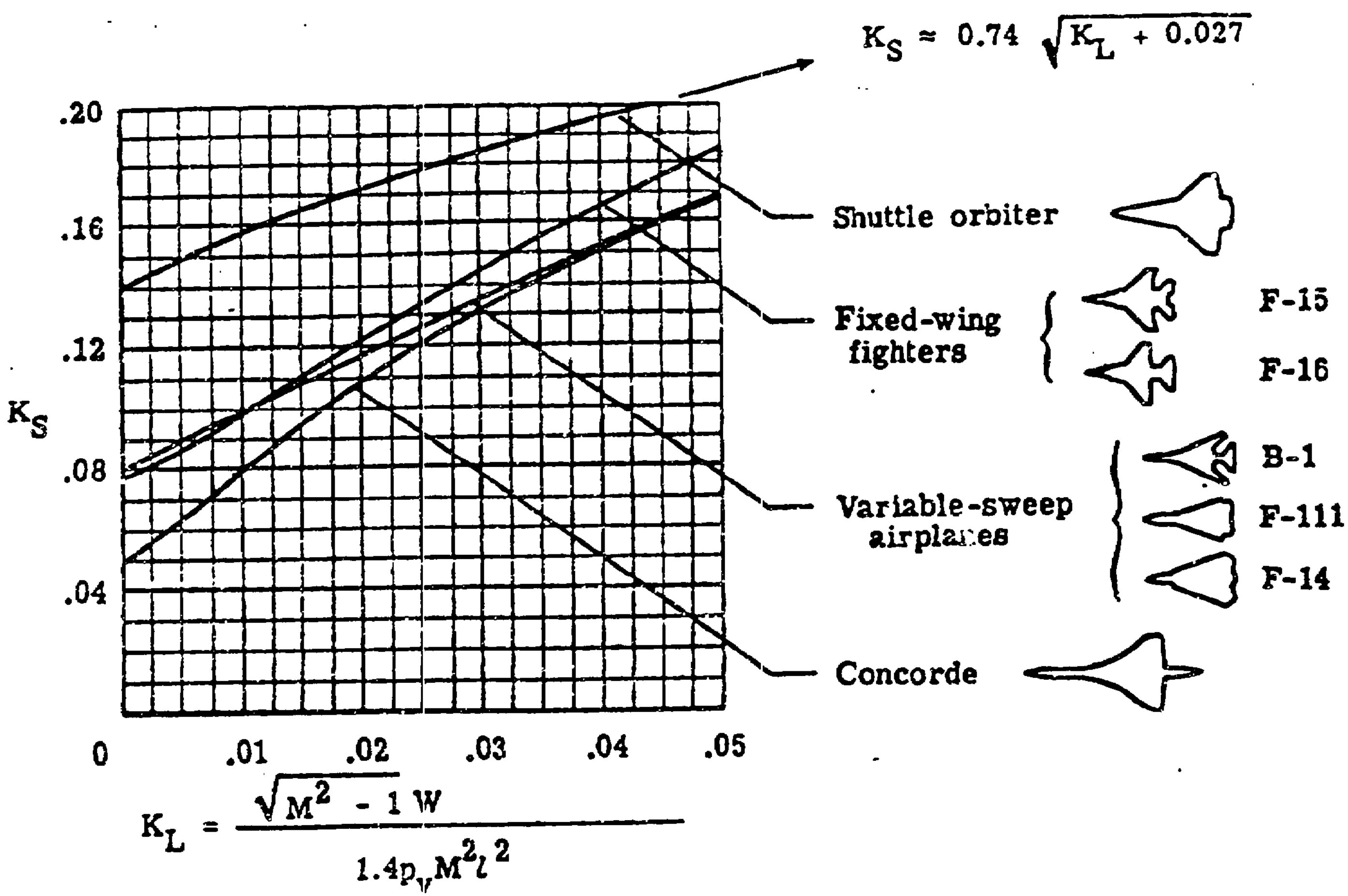
(2) Enter altitude $h_v$ and Mach number M

Read pressure amplification factor $K_p$

(3) Calculate bow-shock overpressure

$$\Delta p_{max} = 2\, K_p K_S \sqrt{p_v p_g}\ (M^2 - 1)^{1/8} h^{-3/4} l^{3/4}$$

Figure 3 - Super-simplified sonic-boom prediction method for on-track bow-shock overpressure of conventional airplanes in level flight.W




(b) Contemporary aircraft.

Figure 3 - Concluded.

TABLE I

SONIC BOOM INTENSITY* DIRECTLY UNDER FLIGHT TRACK

| Aircraft | F-4 | | | | F-15 | | | | F-16 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aircraft Altitudes (ft) MSL | 15000 | 20000 | 25000 | 30000 | 15000 | 20000 | 25000 | 30000 | 10000 | 15000 | 26000 | 25000 |
| Pressure at Altitude ($P_y$) | 1194.3 | 972.5 | 785.3 | 628.4 | 1194.3 | 972.5 | 785.3 | 628.4 | 1455.3 | 1194.3 | 972.5 | 785.3 |
| Aircraft Weight (W) | 36,100 lb | | | | 40,000 lb | | | | 23,500 lb | | | |
| Aircraft Length (Z) | 58.0 ft | | | | 64.0 ft | | | | 47.5 ft | | | |
| Shape Factor ($K_s$) M=1.1 | 0.080 | 0.082 | 0.084 | 0.086 | 0.080 | 0.081 | 0.083 | 0.085 | 0.079 | 0.080 | 0.081 | 0.083 |
| ($K_s$) M=1.4** | 0.082 | 0.084 | 0.087 | 0.090 | 0.082 | 0.084 | 0.086 | 0.088 | 0.080 | 0.081 | 0.083 | 0.085 |
| Pressure Factor ($K_p$) M=1.1 | 1.03 | 1.05 | 1.07 | 1.11 | 1.03 | 1.05 | 1.07 | 1.11 | 1.02 | 1.03 | 1.05 | 1.07 |
| ($K_p$) M=1.4** | 1.02 | 1.03 | 1.04 | 1.05 | 1.02 | 1.03 | 1.04 | 1.05 | 1.01 | 1.02 | 1.03 | 1.04 |
| Normal Ground Pressure @ 5000 ft | 1760.8 PSF | | | | 1760.8 PSF | | | | 1760.8 PSF | | | |
| @ 6000 ft | 1695.9 PSF | | | | 1695.9 PSF | | | | 1695.9 PSF | | | |
| ΔP (psf) @ MACH 1.1 5000 ft | 3.92 | 2.73 | 2.07 | 1.65 | 4.23 | 2.90 | 2.20 | 1.77 | 6.36 | 3.52 | 2.40 | 1.81 |
| 6000 ft | 4.17 | 2.82 | 2.11 | 1.63 | 4.49 | 3.00 | 2.24 | 1.79 | | 3.78 | 2.53 | 1.89 |
| ΔP (psf) @ MACH 1.4 5000 ft** | 4.82 | 3.32 | 2.51 | 1.99 | 5.19 | 3.57 | 2.67 | 2.09 | 7.48 | 4.14 | 2.85 | 2.14 |
| 6000 ft | 5.12 | 3.42 | 2.56 | 2.01 | 5.51 | 3.69 | 2.73 | 2.11 | | 4.40 | 2.95 | 2.18 |

*Aircraft in steady rectilinear flight.

**F-16 Data is at M=1.3

TABLE 2

SONIC BOOM CUTOFF DISTANCE AND INTENSITY AT CUTOFF

| AIRCRAFT | F-16 | | | |
|---|---|---|---|---|
| Altitude (ft) MSL | 10,000 | 20,000 | 15,000 | 25,000 |
| Mach Number | 1.1 MACH | | | |
| Ground Altitude (ft) MSL | 5,000 | | 6,000 | |
| Cutoff Distance (ft) | 18,810 | 22,540 | 22,280 | 18,390 |
| COS | 0.257 | 0.554 | 0.375 | 0.719 |
| Slant Range in ft (r) | 19,460 | 27,040 | 24,030 | 26,440 |
| Shape Factor (Ks) | 0.079 | 0.081 | 0.080 | 0.083 |
| Pressure Factor (Kp) | 1.02 | 1.05 | 1.03 | 1.07 |
| p Overpressure at 0.8 Cutoff | 2.68 | 1.72 | 2.08 | 1.58 |
| p Overpressure at Cutoff* | 0.85 | 0.54 | 0.66 | 0.50 |
| Width of Audible Boom (statute miles) | 7.1 | 8.5 | 8.4 | 7.0 |

* Approximate values taking into consideration the disintegration of the sonic boom wave as it travels the distance between 80 and 100 percent cutoff distance.

C-Weighted Sound Exposure Level:

The C-weighted sound exposure level, CSEL, used to calculate C-weighted day-night average sound level for sonic booms caused by F-16 aircraft is given approximately by:

$$L_{CE} = 178 + 10 \log_{10} \delta_v \delta_g + 2.5 \log_{10} (M^2 - 1) - 15 \log_{10} r$$

where:

$\delta_v$ is the ratio of atmospheric pressure of aircraft height to sea level pressure

$\delta_g$ is the ratio of atmospheric pressure at an observer's ground elevation to sea level pressure

M is the aircraft Mach number

r is the slant distance from aircraft to the observer.

As an example, the C-weighted sound exposure level for an aircraft at 20,000 feet MSL, flying at Mach 1.1, directly underneath the flight path at an observer elevation of 3,000 feet MSL is 109.2 decibels.

C-Weighted Day-Night Average Sound Level Calculations:

As identified earlier in this Appendix, the C-weighted day-night average sound level, CDNL, can be calculated from the expression:

$$L_{Cdn} = \overline{L_{CE}} + 10 \log_{10} (N_d + 10 N_n) - 49.4$$

The term $\overline{L_{CE}}$ is the logarithmic average of the C-weighted sound exposure level (CSEL) of individual booms and was calculated for the purposes of this proposal using the following rationale:

The preceeding equation for the term $L_{CE}$ yields the CSEL at a single point directly below the flight path. Points to the side of the flight path, up to a cutoff, will have decreasing sound exposure levels as the distance from the flight path increases. In addition, the extent of exposed areas along the flight path will depend on how long the aircraft remains supersonic. Along the flight path, directly underneath, the boom will travel a distance equal to the aircraft speed times the duration of supersonic flight. Air Force statistics on high performance fighters during combat maneuvers indicate 15 seconds is an average duration for supersonic speeds. The average aircraft elevation and supersonic speed anticipated for the proposed airspace is 20,000 feet MSL (15,000 feet AGL) and Mach 1.1 respectively. At Mach 1.1, the distance traveled in 15 seconds, at 20,000 feet MSL altitude, is approximately 17,100 feet and the lateral cutoff for the boom produce is about 22,540 feet.

Directly underneath the flight path the CSEL remains constant. The CSEL to the side of the flight path decreases by 15 times the logarithm of the ratio of slant distance to aircraft height above ground, up to a lateral distance equal to approximately 0.8 times the lateral cutoff. The sonic boom wave disintegrates rapidly into a rather ragged sine wave of much lower pressure as the lateral distance approaches cutoff. Following Ref. FF, CSEL is assumed to decrease by 10 additional decibels as the ratio of lateral distance to $d_y$ increases from 0.8 to 1.0. The boom CSEL is considered negligible at greater lateral distances. With aircraft height of 20,000 feet MSL (15,000 feet AGL), and a lateral cutoff distance of 22,540 feet, the CSEL at 0.8 of lateral cutoff, or 18,030 feet, is 2.9 decibels lower than directly beneath the flight path, and approximately 13 decibels lower at 22,540 feet.

The CSEL along the boom carpet, directly under the aircraft, is constant. The space average CSEL over the boom area is the energy mean average sound level from 0.8 times the lateral cutoff distance on one side of the boom width to the sound level overhead. This space average value is approximately 1.1 decibels below the overhead level for the described situation.[GG] The space average CSEL per home is thus 109.2 - 1.1 = 108.1 decibels over an area with dimensions of 17,100 feet along the flight track (3.2 miles), 18,030 feet to each side (3.4) miles), for a total area of 22 square miles.

If all booms generated in the proposed supersonic flight airspace occurred such that the same 22 square mile ground area was impacted, then the space average CSEL of 108.1 decibels could be used to calculate the day-night average sound level, CDNL, for that area. However, the booms will not be occurring at the same location. The Air Force studied air-to-air combat maneuvers in the Oceana MOA to determine the actual areas where sonic booms would be created. The aircraft used in the study were F-15s, but the analysis is being used to approximate F-16 operations for the purpose of this document.

In Ref. GG the Oceana data was analyzed and it was learned that the traces of a number of flight paths show that, except for entry and exit of the MOA, maneuvers were concentrated in an area roughly of an elliptical shape. The origin of the ellipse was at a geographical location that is midway between two navigational reference points, approximately 40 miles apart, the major axis of the elipse being along this line.

For F-15 maneuvers, the aspect ratio of the ellipse surrounding the maneuvering area was approximately 1.7:1, or 20 miles wide by 34 miles long, covering approximately 534 square miles. Within this area, supersonic flight was contained within a smaller ellipse, with the same origin and principal "axes" as the larger, having an aspect ratio of 1.5:1, with dimensions of approximately 12 miles wide by 18 miles long, enclosing an area of approximately 170 square miles.

Traces of representative flight tracks indicated that in the Oceana data an aircraft could be at any location within the ellipses during a sortie. On average, the F-15 made 0.8 booms propagating to the ground per sortie, of 15 seconds duration, during a 20 minute sortie. That is, during 0.010 of the time the aircraft was within the supersonic maneuvering area it was, on the average, causing a propagating boom that reaches the ground. The randomness of the flight tracks within the supersonic area, and the low probability of occurrence lead to a first order assumption that the probability of a boom being experienced on the ground is a random process having a Poisson distribution function. The expected rate of boom production, and resultant CSEL are as described above; the geographical location of the aircraft when causing a boom is equally probable at any point within the supersonic maneuvering area.

The above assumptions lead to the computation that the space average CSEL per boom within the supersonic maneuvering ellipse is the space average CSEL per boom, reduced by 10 times the logarithm of the ratio of the area per boom to the area of the supersonic maneuvering area,

$$L_{CE} = CSEL - 10 \log_{10} \left[ \frac{(\text{maneuvering area})}{(\text{boom area})} \right]$$

In the case of the F-16 where the space average CSEL has been determined to be 108.1 decibels and the area per boom is 22 square miles.

$$L_{CE} = 108.1 - 10 \log_{10} \left( \frac{170}{22} \right) = 99.2 \text{ decibels}$$

Since the flights are assumed to occur anywhere within the supersonic maneuvering area, including along its periphery, a larger area outside this boundary will be exposed to somewhat lower sound levels, out to 0.8 times the cutoff distance, or 3.4 miles to the side of the flight track. This defines an outer ellipse with dimensions of 18.8 miles total width by 24.8 miles length with a long term averager CSEL of 99.2 - 2.9 = 96.3 decibels along the boundary. A third ellipse, corresponding to the cutoff boundary, has dimensions of 21.4 miles in width and 27.4 miles in length, with a boundary CSEL of 86.3 decibels. With these computations, the C-weighted day-night average sound level can be computed for the cumulative effect of operations.

In the proposed supersonic flight airspace it is anticipated that there will be three separate ellipses where supersonic maneuvering wil take place. In the worst case condition (1,050 supersonic sorties being flown in this airspace in one month) it is further anticipated that the north and middle ellipses will carry about 400 supersonic sorties each with the south ellipse taking the remaining 250 supersonic sorties. Assuming each supersonic sortie produces an average of 2.5 booms and 0.3 of these actually reach ground level, the land areas beneath the north and middle ellipses will be subjected to 300 booms per month or about 14 booms per day and the land beneath the south ellipse will be subjected to 188 booms per month or about 9 booms per day.

The C-weighted day-night average sound level (CDNL) for the land areas beneath these ellipses can then be calculated using the equation identified at the beginning of this section.

North and Middle Ellipses: With 14 booms created per day, 5 days per week, 52 weeks per year, the long term average number of daily operations is:

$$14 \times 5/7 = 10$$

and the space average CDN L within the elliptical supersonic maneuvering area having dimensions of 12 by 18 miles is:

$$\overline{L_{Cdn}} = 99.2 + 10 \log_{10} 10 - 49.4 = 59.8 \text{ decibels}$$

The ellipse at 0.8 times cutoff distance, 18.8 miles wide by 24.8 miles long, has a CDNL of 59.8 - 2.9 = 56.9 decibels. The outer ellipse, defining the outer cutoff boundary, 21.4 miles wide by 27.4 miles long, has a CDNL of 46.9 decibels.

South Ellipse: With 9 booms created per day, 5 days per week, 52 weeks per year, the long term average number of daily operations is:

$$9 \times 5/7 = 6.4$$

and the space average CDNL within the elliptical supersonic maneuvering area having dimensions of 12 by 18 miles is:

$$\overline{L_{Cdn}} = 99.2 + 10 \log_{10} 6.4 - 49.4 = 57.9 \text{ decibels}$$

The ellipse at 0.8 times cutoff distance, 19.8 miles wide by 24,8 miles long,has a CDNL of 57.9 - 2.9 = 55.0 decibels. The outer ellipse, defining the outer cutoff boundary, 21.4 miles wide by 27.4 miles long, has a CDNL of 45.0 decibels.

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# APPENDIX C

## PROBABILITY OF SONIC BOOMS OCCURRING AT VARIOUS POINTS IN GANDY RANGE EXTENSION

# APPENDIX C

## PROBABILITY OF SONIC BOOMS OCCURING

## AT VARIOUS PONTS IN GANDY RANGE EXTENSION

Probability, p, of a single boom being heard in elliptical operating area when only one boom is generated is:

$$p = \frac{\text{carpet area}}{\text{ellipse area}}$$

$$p = \frac{22 \text{ sq mi.}}{170 \text{ sq mi.}} = 0.13$$

Probability of y booms being heard when n booms are generated is:

$$P(Y) = C^n_y \, p^y \, q^{n-y}$$

y = number of booms

n = number of booms generated

p = probability of a single boom being heard when only one boom is generated in the airspace

$C^n_y$ = combination of n things, taken y at a time = $\frac{n!}{(y!)\ (n-y)\ !}$

This assumes that there is an equal chance that an aircraft will be located at any point in the elliptical operating area.

The average number of carpet booms generated in a single day in either the northern or central ellipse is:

$$n = \frac{400 \frac{\text{sorties}}{\text{month}} \times 2.5 \frac{\text{booms generated}}{\text{sortie}} \times 0.3 \frac{\text{booms to Ground}}{\text{booms generated}}}{22 \frac{\text{days}}{\text{month}}}$$

$$= 13.6 \approx 14$$

PROBABILITY OF SONIC BOOMS OCCURRING AT VARIOUS POINTS IN GANDY RANGE EXTENSION (Continued)

| No. of booms | Probability of hearing given no. of booms on a single day | Probability of hearing given no. or more booms on single day |
|---|---|---|
| 0 | 0.14 | 1.00 |
| 1 | 0.30 | 0.86 |
| 2 | 0.29 | 0.56 |
| 3 | 0.17 | 0.27 |
| 4 | 0.07 | 0.10 |
| 5 | 0.02 | 0.03 |
| 6 | 0.01 | 0.01 |
| 7 | <0.01 | <0.01 |
| 8 | <0.01 | <0.01 |
| 9 | <0.01 | <0.01 |
| 10 | <0.01 | <0.01 |
| 11 | <0.01 | <0.01 |
| 12 | <0.01 | <0.01 |
| 13 | <0.01 | <0.01 |
| 14 | <0.01 | <0.01 |

Above numbers apply to the northern and central ellipses.

PROBABILITY OF SONIC BOOMS OCCURRING AT VARIOUS POINTS IN GANCY RANGE EXTENSION (continued)

For southern ellipse

$$\text{Expected no. of booms} = \frac{250 \times 2.5 \times 0.3}{22}$$

$$= 8.25 \approx 9 \ \frac{\text{booms}}{\text{day}}$$

| No. of booms | Probability of hearing given no. of booms on a single day | Probability of hearing given no. or more booms on a single day |
|---|---|---|
| 0 | 0.29 | 1.00 |
| 1 | 0.38 | 0.71 |
| 2 | 0.23 | 0.33 |
| 3 | 0.08 | 0.10 |
| 4 | 0.02 | 0.02 |
| 5 | <0.01 | <0.01 |
| 6 | <0.01 | <0.01 |
| 7 | <0.01 | <0.01 |
| 8 | <0.01 | <0.01 |
| 9 | <0.01 | <0.01 |